EXPERIMENTAL PROCEDURE

*Eryophyllum tubiflorum* Herv. belonging to family Crassulaceae; *Dalbergia sissoo* L. to Leguminosae and *Salmalia malabarica* Schott, and Endl. to Bombacaceae were used as experimental material in this investigation.

Plants were raised from epiphyllous buds in the case of *E. tubiflorum* and from seeds in the other two cases, in 23 cm dia. earthen-ware pots (unless mentioned otherwise), containing 1:1 mixture of garden-soil and farmyard manure. For rooting trials fifteen cm long stem cuttings were made from the detopped and defoliated branches, except in *Eryophyllum tubiflorum* where 6 upper leaves were left intact on the cuttings.

**Light and Temperature Treatments**

The mother plants or stem cuttings were exposed to one or more of the following light and temperature conditions depending upon the experiment as described separately in each case.

**Photoperiod:** The three photoperiodic treatments given to mother plants or the cuttings were as follows: (a) short days (*SD*<sub>5</sub>) consisting of 8 hours of light alternating with 16 hours of dark; (b) normal days (*ND*<sub>5</sub>) consisting of natural daily photoperiod at Chandigarh (Fig.1) and (c) long days (*LD*<sub>5</sub>) consisting of 24 hours illumination. For *SD*, natural day length was curtailed by screening the plants with thick canvas sheets daily from 17.00 to 9.00 hr
and for LD, the daylight was supplemented by two 200 watt incandescent filament lamps (intensity 400 lux) maintained at a distance of 4 ft from the cuttings.

**Light intensity:** The three light intensities to which mother plants or cuttings were exposed, were (a) the intensity of sunlight at Chandigarh during the period of experimentation (10,000-15,000 ft. candles); (b) 1,000 ft C. and (c) 100 ft C. The last two intensities were obtained by shading the mother plants or cuttings. The intensity of light was measured by means of a Weston Luxmeter at plant level.

**Light quality:** In experiments on the effect of quality of light, the cuttings were exposed to (a) blue; (b) green; (c) yellow; (d) red and (e) white lights obtained by filtering the fluorescent light through double layers of cellophane paper of the respective colour.

**Temperature:** To study the effect of temperature on rooting, the cuttings were planted and maintained at (a) 35±2°C; (b) 25±2°C and (c) 15±2°C, respectively. The high temperature (35°C) was obtained by keeping cuttings in a closed chamber heated with incandescent electric bulbs; the medium by keeping them in an air-conditioned room and the low by keeping them on the lowest shelf of a refrigerator.

**Treatment with Growth Regulatory Substances**

The basal 5 cm portion of the cuttings was dipped in the solution of growth regulators for 24 hours. The
growth regulators used in this investigation were IAA, IBA
and GA₃. Two concentrations, namely, 10 and 100 ppm were
used in each case and control cuttings were dipped in
distilled water for the same period. The stock solutions
were prepared by dissolving the chemical in a few drops
of alcohol and added distilled water to make it to a
definite volume and stored in a refrigerator. These were
diluted with distilled water as and when required.

Observations

The observations for the number of cuttings that
rooted and the number and length of roots produced on
them were recorded at regular intervals.

Anatomical Studies

For anatomical studies, samples of stem cuttings
were fixed in 1:3 acetalcohol at regular intervals. The
material was dehydrated in ethylalcohol-xylol series
(Johansen, 1940), was embedded in paraffin wax and serial
transverse sections, 10-15 µ thick, were cut with a rotary
microtome. The ribbons were floated on 3% formalin water
and were affixed to slides with Haupt's adhesive.

For studying the changes in anatomical structure
with age, sections 20-40 µ thick were cut from the basal
portion of stem cuttings fixed in 1:3 acetalcohol with
a sliding microtome. Sections in both cases were stained
with safranine-fast green. Photomicrographs were taken
at important stages.
Chemical Analysis

Determinations were also made on the contents of nitrogen, total soluble carbohydrates, starch and the activity of hydrolytic enzymes. The methods used for these determinations were as follows:

Nitrogen: Total nitrogen was determined by 'microkjeldahl' method. The determination of each sample was replicated 3 times. The following steps were involved in determination:

Digestion: Twenty mg dried and powdered plant material was taken in a microkjeldahl flask and was digested on an automatic 'Gallenkemp' digestion apparatus, after adding a pinch of 20:1 mixture of $\text{K}_2\text{SO}_4$ and $\text{CuSO}_4$ and 1 ml of conc. $\text{H}_2\text{SO}_4$ (Analar). In the beginning the heater was kept at a low temperature, shaking the flasks frequently but taking care that nothing remained sticking to the sides. When the solution turned uniformly dark brown, it was subjected to strong heat for two hours, taking care to avoid spurting of the material till the liquid was colourless or transparent apple-green in colour. The liquid was, then, allowed to cool.

Distillation: The microkjeldahl distillation unit was cleaned by passing steam for 10 minutes. The heater was then put off and the apparatus was washed for 3-4 times allowing distilled water to pass from the open end.

After cooling, the contents were transferred to a distillation flask and 20 ml distilled water and 10 ml
sodium hydroxide (33%) were added to it. On heating, steam passed through the reaction mixture and the distillate was collected in a titration flask containing 1 ml 0.01 N H_2SO_4, 10 ml distilled water and 2 drops of double indicator (made by dissolving 0.1 gm methyl red and 0.2 gm methylene blue in 200 ml ethyl alcohol). To begin with the colour of the liquid in the titration flask was violet but it changed to light green later, when ammonia from the distillate accumulated in excess. for 10 minutes. The heater was, then, removed.

**Titration:** The excess of ammonia present in the titration flask was titrated against 0.01N H_2SO_4. The total quantity of the acid used was calculated by adding to the value the amount of acid used in the back titration to 1 ml which was already present in the flask.

**Calculations:** The quantity of nitrogen present in the sample was calculated as follows:

Total quantity of acid x 0.01N x 14 = mg of N present.

The percentage of \( \frac{\text{mg of N present}}{\text{mg of sample taken}} \) x 100

**Blank:** Whenever fresh acid (0.01N H_2SO_4) catalysing mixture (CuSO_4+K_2SO_4), indicator or distilled water were prepared, a blank parallel to the actual estimation was run.

**Protein nitrogen:** Hundred mg powdered sample was crushed in a little quantity of 70% ethyl alcohol to a fine paste.
which 15 ml ethyl alcohol was added more and the whole solution was transferred to a test tube and boiled on a water-bath for 30 minutes. The liquid was, then, allowed to cool, filtered through Whatman paper No. 41 and 2 ml of 5% trichloroacetic acid was added to the filtrate. The tubes were left overnight and the contents were filtered the next day using the same type of filter paper.

The filter paper as well as the tubes were suitably marked and residue dried. The dried filter paper along with the residue was digested, distilled and titrated as described above for total nitrogen.

**Calculations:** The quantity of protein nitrogen was calculated by the formula described for total nitrogen on page 56.

**Blank:** A blank with the filter paper without the material was digested, distilled and the amount of acid used in titration was determined. This value was subtracted from the quantity of the acid used in the actual estimation.

**Starch content:** For determining the content of starch samples were extracted with boiling methanol to free it from fats and fatty acids that hinder the dissolution of starch, depress the intensity and alter the colour of iodine-potassium iodide solution. After drying in the air, the ground tissue was extracted with cold water in centrifuge tube. After shaking and centrifuging, the washings were tested with iodine-potassium iodide solution (0.2% iodine in 2% of KI solution), 0.5N NaOH was then
added and mixture was allowed to stand for an hour at room temperature followed by heating for 2 minutes in a boiling water-bath. The solution was cooled and was neutralised with 0.5N HCl. One drop of HCl was added in excess (using phenolphthalein as an indicator). The solution was diluted to 25 ml, filtered and divided into 5 samples with 5 ml each. Iodine-potassium iodide solution (0.2 ml) was added, the solution was shaken and the readings taken on 'Bausch and Lomb' 'Spectronic 20' photocalorimeter. The concentration of starch was determined from the standard graph prepared previously by taking the known concentrations of starch.

Soluble carbohydrates: About 1 gm powdered material was dried at 100°C for 4-6 hrs, 0.1 gm of the material was weighed accurately after cooling it in a desiccator. The weighed material was transferred to 250 ml conical flask and 50 ml of 80% ethyl alcohol was added to it and boiled on a water-bath for about one hour after which it was left at room temperature. The supernatent was decanted into another 250 ml flask. The extraction procedure was, then, repeated with 40 ml of cold 60, 40 and 30% alcohol, respectively and finally with cold distilled water for 24 hours in each case. The extracts were made upto 250 ml each. An aliquot of 25 ml was pipetted out in a chinadish for the next step.

Clarification: The alcohol aliquot was evaporated over
boiling water. When all the alcohol had evaporated, 1 ml of lead acetate (neutral) was added and the solution was filtered through a Whatman paper No. 40. Three ml of disodium phosphate was added to the filtered solution to precipitate the excess of lead acetate. The solution was filtered, and made upto 100 ml.

**Inversion of sugars:** A 10 ml clarified aliquot was hydrolysed with 0.5N HCl using 1 ml of acid for every 2 ml clarified solution on a boiling water-bath for ½ hour. The solution was cooled, neutralised with 0.5N NaOH using phenol-red as an indicator. It was again made slightly acidic with 0.1N oxalic acid and the solution was made upto 100 ml.

**Estimation:** Soluble carbohydrates were estimated by the method described by Somogyi (1945) as follows:

**Reagents:**

1. **Phosphate reagent:** (1) 56 gm of Na₂HPO₄ (Analar) and 80 gm of Rochelle salt (sodium potassium tartrate) were dissolved in about litre of distilled water and 200 ml. of 1N NaOH was added to it followed by 160 ml of 10% CuSO₄ (SH₂O) with vigorous stirring. After copper sulphate went into solution, 360 gm of anhydrous Na₂SO₄ was added and vigorously stirred into solution. The solution was, then, transferred to a 2 litre flask and exactly 200 ml of 0.1N KIO₃ (3.567 gm of analar salt/litre) was added and the solution was made to 2 litres. It was stored in a
cool dark place and filtered before use.

(ii) Potassium iodide: 2.5 gm of KI was made upto 100 ml with distilled water.

(iii) Sodium thiosulphate: 27.3 gm of crystalline Na\textsubscript{2}S\textsubscript{2}O\textsubscript{3} was made to exact 1 litre. It was diluted to make fresh 0.005 N solution at the time of titration. Chloroform, 0.5 ml was also added to the solution and was placed in a refrigerator.

(iv) 2N H\textsubscript{2}SO\textsubscript{4}

(v) Starch indicator: 1 gm of pure starch of potato was suspended in cold water. This was poured into 200 ml of boiling distilled water containing 0.2 gm of salicylic acid.

Titration: Five ml of inverted sugar solution, 5 ml of somogyi's reagent and 5 ml of distilled water were added and placed in boiling water-bath for exactly 15 minutes. The tubes were removed from the bath without disturbing the contents and were cooled in running water. Exactly 1 ml of KI solution was added with 2 ml of 2N H\textsubscript{2}SO\textsubscript{4} with vigorous stirring to bring cuprous oxide into the solution. The excess of iodine was titrated against freshly prepared 0.005N Na\textsubscript{2}SO\textsubscript{3}. When the colour of liquid turned pale-yellow, 2-3 drops of starch indicator were added and the titration was carried till the solution became colorless.

Blanks were also run parallel to samples.

Calculations:

Na\textsubscript{2}S\textsubscript{2}O\textsubscript{3} used for the blank - Na\textsubscript{2}S\textsubscript{2}O\textsubscript{3} used for the sample = volume used
This volume used x titration factor
= Amount of soluble carbohydrates present in 5 ml

The percentage of soluble carbohydrates = \[ \frac{\text{Amount of carbohydrate present}}{\text{Weight of sample}} \times 100 \]

**Activity of hydrolysing enzymes:** One gram basal 2-3 cm portion of the cuttings was washed thoroughly and was crushed with 10 ml of cold distilled water. The extract was centrifuged at a speed of 2,000 g for 15 minutes and the supernatant was collected and its volume was made to 20 ml. This crude extract was stored in a refrigerator at 15°C till used.

Ten ml of 0.1% starch solution along with 5 ml of citrate-phosphate buffer at pH 7.0 was taken in 50 ml Corning test tube. Five ml of plant extract was added to it and the reaction mixture was incubated at 30°C for 24 hours. After incubation, the reaction was stopped by 2 ml of IN HCl and 0.2 ml of I₂-KI solution (6% KI and 0.6% I₂ v/m) added and its optical density was measured colorimetrically using a yellow filter. The amount of starch hydrolysed was determined by comparing the optical density of the mixture against the standard curve of different concentrations of starch.

**Calculations**

\[ \text{Amount of starch taken} - \text{Amount of starch remained in the solution} = \text{Amount of starch hydrolysed} \]

The percentage of hydrolytic activity = \[ \frac{\text{Amount of starch hydrolysed}}{\text{Amount of starch taken}} \times 100 \]
EXPERIMENTAL FINDINGS

A number of experiments were carried out which have been discussed under three main heads: those dealing with factors affecting rooting; those relating to the study of biochemical changes that occur during the initiation and development of roots and those relating to their origin. The objective of the experiment, details of experimentation together with the species used, the treatments given and the observations recorded are given separately in individual experiments.

FACTORS AFFECTING ROOTING

The experiments under this section deal with the study of the effect of auxins on rooting of stem cuttings under varying environmental conditions and plant factors, such as season, age, light and temperature. The following experiments were carried out:

(a) Auxin Effects on Seasonal Rooting Response

Experiment 1: This experiment was designed to study the effect of auxins on the seasonal rooting response of stem cuttings of Bryophyllum tubiflorum, Dalbergia sissoo and Salmalia malabarica.

The experiment was started in May, 1966. Stem cuttings were taken in February, May, August and November and were divided into 5 groups each time; group 1 to be treated with water to serve as control, and groups 2-5 with 10 and 100 ppm IAA and IBA, respectively for 24 hours. After
the treatments cuttings were planted in pots under natural conditions of photoperiod and temperature obtaining at Chandigarh (Fig.1) and observations were recorded for the number of cuttings that rooted and the number and length of roots produced at weekly intervals in *B. tubiflorum* and fortnightly in the case of *D. sissoo* and *S. malabarica*.

The results are presented in Figs.2-4, 5-7 and 8-10 for *B. tubiflorum*, *D. sissoo* and *S. malabarica*, respectively.

**Bryophyllum tubiflorum**

**Number of cuttings rooted**: It is observed that in February roots appeared after 14 days, the number of rooted cuttings being higher with 10 ppm IAA and 100 ppm IBA than in control. However, all cuttings rooted in all cases after 21 days (Fig.2). In May, roots on auxin treated cuttings emerged after 14 days but on controls after 21 days, the number of rooted cuttings increasing with time in control and with 10 ppm IAA but very little with other treatments.

In August, roots appeared within 7 days, the number of rooted cuttings being higher with both concentrations of IBA and 10 ppm IAA than in control. The number increased with time, the increase being more with 100 ppm IAA and IBA after 14 days. In controls, the number of rooted cuttings increased more after 28 days.

In November rooting was considerably delayed and only 2 out of 10 cuttings rooted with 100 ppm IBA.
after 21 days and 8 with 10 ppm IBA after 28 days, control and other cuttings not rooting at all till the termination of the experiment after 28 days (Fig. 2).

**Number of Roots:** In February, rooting on cuttings was scarce even after 14 days, the number being the highest on 100 ppm IBA-treated ones. The number increased in all cases after 21 days but did not change after that, the effect being more pronounced with 100 ppm IAA and IBA than on control or with 10 ppm auxin treatment (Fig. 3).

In May roots on auxin-treated cuttings appeared after 14 days, the number increasing with concentration. In control, roots emerged after 21 days but the number was more on auxin-treated cuttings, increasing with concentration of IAA but decreasing with that of IBA. The number of roots decreased after 28 days showing that some of the roots dried, probably because of high temperature prevailing during this part of the year.

In August, although roots appeared even after 7 days, their number was very low. The number increased appreciably with 100 ppm of both IAA and IBA after 14 days but did not change subsequently. In fact, the number decreased to some extent in 100 ppm IAA and IBA treated cuttings.

In November, rooting was rather poor and only a few roots appeared on IBA treated cuttings after 21 days.

**Length of Root:** The length of roots increased with time in all plantings (Fig. 4). In February roots on 100 ppm IAA and IBA treated cuttings were longer than on control.
The increase in length on 10 ppm IBA treated cuttings continued till 28 days while on 100 ppm treated cuttings, roots did not elongate much after 21 days. It is interesting to note that after 21 days roots on IBA treated cuttings were longer but after 28 days these were longer on IAA treated cuttings.

In May, roots did not elongate much during the first 21 days but elongated appreciably after 28 days, being longer on control than on auxin treated cuttings and being the shortest on 100 ppm IBA treated ones.

In August also, the elongation was more with auxin application till 21 days, the effect being more pronounced with 10 ppm IAA and 100 ppm IBA. However, the length did not differ much with the treatment after 28 days. In November, roots did not elongate much except with 10 ppm IBA.

It may be noted that in the respective treatments, roots were longer in February, than in May and August and the shortest in November.

*Dalbergia sissoo*

**Number of rooted cuttings:** Figure 5 shows that in February cuttings did not root even with auxin application till the termination of the experiment after 56 days. In May, roots emerged after 56 days but the number of rooted cuttings was higher in control, IAA being more inhibitory than IBA.

In August while none of the control and 10 ppm IBA treated cuttings rooted even after a lapse of 56 days,
auxin treated ones rooted after 28 days, the number of
rooted cuttings being the highest with 100 ppm IAA, followed
by 100 ppm IBA and 10 ppm IAA. The number did not increase
after 42 days. It may be noted that the number of cuttings
that rooted was much higher in August than in May.

In November, rooting occurred only on 2 and 1
(out of 10), 100 ppm IAA and IBA-treated cuttings, respectively
after 56 days, control and other cuttings not rooting at all.

**Number of roots:** The trends of results of the number of
roots (Fig. 6) were similar to those of the number of cuttings
that rooted discussed in the preceding paragraph (Fig. 5). Thus
in May only a few roots were observed after 56 days while
in August, the number of roots produced with auxin application
was higher than in May even after 28 days.

**Length of root:** The trends of results of the length of roots
(Fig. 7) were more or less similar to those of the number of
roots produced (Fig. 6). It may, however, be noted that in
May planting roots were as long or with some treatments even
longer than in August planting, although the rooting was
delayed to 56 days. In August planting, roots did not elongate
much after 28 days.

**Salvadora malabarica**

In *S. malabarica*, cuttings did not root in any planting
even with auxin application except in March when only one
cutting out of 10 rooted with 100 ppm IBA, producing 2 roots and
elongating to 0.8 cm after 56 days (Figs.8-10).

(b) **Auxin Effects on Seasonal Rooting in Relation to Age**

**Experiment 2:** This experiment was designed to investigate if the auxin effects on seasonal rooting response of stem cuttings reported in previous experiment are modified by the age of the mother plant from which cuttings are taken.

Epiphyllous buds of *Eryophyllum tubiflorum* and seeds of *Dalbergia sissoo* and *Salmalia malabarica* were sown on November 12, March 23 and April 26, 1966, respectively, under natural conditions of photoperiod and temperature at Chandigarh (Fig.1). Stem cuttings from 200 plantlets or seedlings of each species were taken at monthly intervals throughout the year and were divided into 5 groups each for auxin treatment. The treatments given and the observations recorded at weekly intervals were the same as in Experiment 1.

The results are presented diagrammatically in Figs. 11-13 for *B. tubiflorum*, in Figs.14-16 for *D. sissoo* and in Figs.17-19 for *S. malabarica*. In each figure, the age of the plantlet or seedling from which the cuttings were taken is shown (in months) along the vertical line on the left and the month of planting along the vertical line on the right side.

*Eryophyllum tubiflorum*

**Number of cuttings rooted:** The number of *B. tubiflorum* cuttings that rooted at monthly intervals is shown in Fig.11. As the plantlets were very small, cuttings of the requisite size
could not be obtained for rooting trials till these were
5 month old in March, when a few of the 100 ppm IAA and
IBA treated cuttings rooted after 7 days. In control and
10 ppm IAA and IBA treated cuttings, rooting was delayed to
14 days. However, all cuttings rooted in all cases after 21
days.

In May and June, root emergence started after 14
days, the number of rooted cuttings being higher with auxin
application than in control. It may be noted that some of
the 100 ppm IAA and IBA treated cuttings died after 28 days,
this effect being more pronounced in June than in May.

In July, 2 out of 10, 100 ppm IAA treated cuttings
rooted after 7 days, the roots in other cases appearing
after 14 days and being higher than the control with auxin
application. All cuttings rooted after 21 days with all
treatments. As in May and June, in this month also some of
the 100 ppm IAA and IBA treated cuttings decayed after 28
days.

In August and September roots started initiating in
all cases after 7 days and all cuttings rooted after 14 days.
In these planting also, some of the 100 ppm IAA and IBA treated
cuttings decayed after 28 days.

In October, roots could be observed only on 2 and 4
100 ppm IAA and 10 ppm IBA treated cuttings, respectively
after 7 days. In all other cases, rooting occurred after 14
days and the number of rooted cuttings increased with time
and with auxin application, except with IBA where the number
decreased after 28 days.

**Number of roots:** In March, although roots on 100 ppm IBA and IAA treated cuttings started appearing after 7 days, their number was very low. The number of roots increased somewhat with time, being higher in auxin treated than in control cuttings and the effect of IAA increasing slightly with concentration (Fig.12). In May and June also, the number of roots was higher in auxin treated than in control cuttings, being higher with 100 than with 10 ppm of each. The number increased with time till 21 days but decreased after 28 days, showing that some of the roots died during this period. It may be noted that the number of roots produced on cuttings of the respective treatments was higher in June than in May.

As stated in the various section, in July a few roots were initiated on 100 ppm IAA treated cuttings after 7 days. The number remained low even after 14 days but increased after 21 days, being the highest on 100 ppm IBA treated cuttings, followed by 100 ppm IAA and 10 ppm IAA treated ones. The number decreased with higher concentrations of IAA and IBA after 28 days.

In August and September, the number of roots increased with time and with auxin application up to 21 days, the increase being more with higher concentration of both IAA and IBA. The number of roots on 100 ppm IAA and IBA treated cuttings decreased after 28 days in these months also, this effect being more pronounced in August than in September.
In October, a few roots were initiated on 100 ppm IAA and IBA treated cuttings after 7 days. The number increased with time and with auxin application, the effect of higher concentration being more pronounced. A slight decrease in the number of roots on cuttings treated with higher concentration of both auxins was observed after 28 days (Fig.12).

Length of root: In March, root elongation was rather poor and root length did not differ much with the treatment (Fig.13). In May, roots elongated till 21 days, the elongation being more with IBA and not differing much from the control with IAA. While there was no further elongation of roots in IBA and 100 ppm IAA treated cuttings, the elongation continued in control and 10 ppm IAA treated ones and as a consequence of which roots on these cuttings were longer than on IBA and 100 ppm IAA treated ones after 28 days.

In June, root elongation was faster in auxin treated than in control cuttings after 14 days, 10 ppm IAA and IBA being more effective than 100 ppm. However, the length of roots did not differ much subsequently except that on 100 ppm IAA and IBA treated cuttings, roots were shorter than on control. It may also be noted that roots in the respective treatments were the longest in this planting. In July also, roots elongated till 21 days and were longer on auxin treated than on control cuttings. The differences in root length disappeared after 28 days.

In August, roots were longer in control than in auxin treated cuttings after 7 days but on auxin treated ones
subsequently.

In September and October roots on 100 ppm IAA and IBA treated cuttings were shorter than the control after 21 days, the length of roots on 10 ppm auxin treated cuttings not differing much from the control (Fig.13).

It is interesting to observe that the length of roots increased gradually from March to June, decreased from July to August and increased again in September and October.

**Del ber ois s isco**

**Number of cuttings rooted** The results presented in Fig.14 show that while in April all cuttings from one month old seedlings rooted after 7 days, in May rooting was delayed and occurred on 8 control and 4 100 ppm IAA treated cuttings after 21 days, roots not initiating at all in other treatments till the termination of the experiment after 28 days.

In June, when the seedlings were 3 month old, roots were produced on control and 10 ppm of IAA and IBA treated cuttings after 14 days, the number of rooted cuttings being more with 10 ppm IAA. It is interesting to note that while the number of control and 10 ppm IAA treated cuttings that rooted, increased with time, that of 10 ppm IBA treated cuttings did not.

In July, roots emerged in all cases after 14 days and the number of rooted cuttings did not increase with time and did not differ with the auxin treatment except with IAA where the number was much lower than in other cases. In August also, the roots in all cases emerged after 14 days but
the number of rooted cuttings was much higher in 100 ppm IAA and 10 and 100 ppm IBA treated cuttings than in control. The number increased with time, the increase being more in control and 10 ppm IAA, so much so that all the control as well as auxin treated cuttings rooted after 28 days except 8 out of 10, 10 ppm IAA treated ones.

In September, roots on auxin-treated cuttings appeared after 14 days, the number of rooted cuttings increasing with concentration and IBA being more effective than IAA. In control rooting was delayed to 28 days although the number of rooted cuttings was as high as on IBA treated ones.

In October, November and December, cuttings did not root even with auxin application and in January only 2 and 6 cuttings rooted with 10 ppm IAA and 100 ppm IBA, respectively after 36 days, none of the others rooting at all. In March, the root emergence was observed on 10 ppm IAA and 100 ppm IBA treated cuttings after 21 days and with other treatments after 28 days. It is, however, interesting to note that the maximum number of rooted cuttings in this planting was higher in control than with auxin treatment.

In this species, the rooting trials were continued till July next year when the seedlings were 16 months old. The emergence of roots in auxin treated cuttings was hastened to 14 days as was also observed in July of the previous year when the seedlings were only 4 month old. The number of rooted cuttings was slightly more with auxin application than in control after 28 days (Fig.14).
Number of roots: As stated previously in April, all the control as well as auxin treated cuttings rooted after 7 days (Fig.14). The number of roots produced, however, remained low and did not increase much with time. In May, only a few roots appeared on control and 100 ppm IAA treated cuttings after 21 days, the number not increasing with time and being lower than in April in the respective treatments. In June also, a few roots emerged on control and 10 ppm IAA and IBA treated cuttings after 14 days but their number increased with time only on 10 ppm IAA treated cuttings.

In July, the number of roots produced on 10 ppm IAA and IBA treated cuttings was higher than in control after 14 days and did not increase subsequently, although the number of roots on control cuttings increased with time.

In August, the number of roots on 100 ppm IAA and IBA treated cuttings was very high and it increased further after 21 days. In control and 10 ppm IAA and IBA, the increase continued till the termination of the experiment after 28 days, being more with 10 ppm IBA so much so that the number with 10 ppm did not differ from 100 ppm IBA after 28 days.

In September, although in auxin treated cuttings roots were observed after 14 days and their number increased with time, 100 ppm IBA being more effective, in control rooting started after 28 days.

It may be noted that in control, the number of
roots increased from June to July and then decreased in
August and September being much delayed, in auxin treated
cuttings, the number of roots increased from May to August
and decreased in September.

As stated earlier, cuttings did not root during
the period October to December and even in January, a few
roots were produced only on 100 ppm IBA treated cuttings.

In March, a few roots emerged on 10 ppm IAA and
100 ppm IBA treated cuttings after 14 days and in control
and with other treatments after 28 days, although the
number was very low.

It is interesting to note that the number of
roots produced on cuttings taken from 16 month old seedlings
in July was higher than on 12 month old ones in March (Fig.15).

Length of root: In April, the mean root length did not
increase much with time, roots being slightly longer with
IBA but shorter than the control with IAA after 28 days. In
May, roots were slightly longer in control than on 100 ppm
IAA treated cuttings, there being no roots with other
treatments. In June, roots elongated more on 10 ppm IAA
treated than on control cuttings. It may also be noted that
while in control, the mean root length did not differ much
in May and June, the roots on 10 ppm IAA treated cuttings
were much longer in June than in May.

In July, the roots on control cuttings elongated
with time but did not on auxin treated ones. Thus, the roots
on IAA treated cuttings were shorter and on IBA treated ones
the length did not differ much from the control after 28 days. In August, roots on auxin treated cuttings were longer than on control after 14 days, the effect increasing with the concentration of both IAA and IBA. The length increased with time, the increase being more in control, so that roots on 100 ppm IAA and IBA treated cuttings were shorter than the control after 28 days. In September, too, roots elongated with time but were longer on 100 ppm IBA treated than on control cuttings even after 28 days. Roots were not formed on cuttings during the period October to December and only on control and 100 ppm IAA and IBA treated cuttings in January and March.

In July next, roots were produced on control as well as auxin treated cuttings and these elongated appreciably, being longer on 100 ppm IAA and 10 and 100 ppm IBA treated than on control cuttings.

It may be noted that, in general, the mean root length increased from May to August, decreased in September and increased again in July (Fig.16).

Salmalia malabarica

Number of cuttings rooted: The rooting response of S. malabarica is shown in Figs.17-19. It is observed that in May when cuttings were one month old, roots were produced on all cuttings after 14 days except 8 out of 10 on 100 ppm IBA treated ones. In June also, rooting started in all treatments after 14 days but the number of rooted cuttings
increased after 21 days when all the 10 control and 100 ppm IAA and IBA treated cuttings rooted. In July, though rooting was observed after 14 days, the number of rooted cuttings was low. The number increased after 21 days but remained lower than in June till the termination of the experiment after 28 days. In August, only 1-2 cuttings rooted in different treatments after 14 days except with 100 ppm IBA where 6 out of 10 cuttings rooted. Stem cuttings taken from older seedlings did not root at all during September to April (Fig.17).

**Number of roots:** In May, the number of roots produced did not differ from the control with auxin application after 14 days except with 10 ppm IBA (Fig.18). The number increased slightly in all cases after 21 days but not much subsequently. In June, the number of roots increased with time but not with auxin application. In fact, the number was slightly lower than the control with auxin application. In July, the number of roots decreased with 100 ppm IAA and IBA but in August the number of roots was the highest on 100 ppm IBA treated cuttings, only a few emerging in other cases. No roots were produced on cuttings taken from older seedlings during September to April (Fig.18).

**Length of root:** In May, roots on 100 ppm IAA and 10 ppm IBA treated cuttings were longer than control after 14 days and did not elongate much after that. In June, the roots elongated appreciably after 14 days and more so after 21 days, the length not differing much with the treatment. In July,
the roots on control cuttings were longer than on auxin treated ones and elongated with time in all cases. However, elongation during the period 21-26 days was more in auxin-treated than in control cuttings and as a consequence of which the differences in root length between control and auxin-treated cuttings were less marked after 28 days than previously.

In August, root length on 100 ppm IBA treated cuttings increased appreciably with time and there was no rooting at all in subsequent months.

(c) Auxine Effects on Rooting with Age

Experiment 3: In the previous experiment, stem cuttings of varying ages were available for rooting trials in different months and the differences in rooting response, therefore, could be ascribed either to seasonal changes or to age or to both. This experiment was designed to study the effect of age on the rooting of stem cuttings without the involvement of seasonal differences.

Plaintlets of *Bryophyllum tubiflorum* and seedlings of *Dalbergia sissoo* of varying ages were obtained simultaneously by sowing the epiphyllous buds and seeds respectively at 3 month intervals starting September 12, 1966 in the former, and April 22, 1966 in the latter case. Stem cuttings from plants of different ages were simultaneously taken for rooting trials on August 12, in the former and on July 22, 1967 in the latter case. As the number of *B. tubiflorum* cuttings that were available was not adequate, the auxin
treatment as described in experiment 1 was given only
to D. sissoo cuttings.

The observations recorded were the same as in
experiment 1 and were taken at weekly intervals in
B. tubiflorum and fortnightly in D. sissoo.

The results are presented graphically in Figs. 20-22
for B. tubiflorum and Figs. 23-25 for D. sissoo.

Bryophyllum tubiflorum

Number of cuttings rooted: The results presented in Fig. 20
show that cuttings from 3-9 month old plantlets rooted
after 14 days, the number of rooted cuttings decreasing
with age. All cuttings of all ages rooted after 21 days.

Number of roots: The number of roots per cutting did not
differ significantly in cuttings of different age groups
upto 21 days but was much higher than others on cuttings
from 1 year old plantlets after 28 days (Fig. 21).

Length of root: The roots on cuttings from younger
plantlets were longer till 21 days but on those from 12
month old plantlets were longer after 29 days (Fig. 22).

Delbergia sissoo

Number of cuttings rooted: Fig. 23 shows that 3 month old
control cuttings did not root even after 28 days while
these rooted with auxin application after 14 days, the
number of rooted cuttings increasing with the concentration
of IBA. However, most of the cuttings decayed so that only a few 10 ppm IBA treated ones survived after 28 days. Rooting on 6-month old cuttings occurred after 14 days, the number of rooted cuttings being higher with auxin application and increasing slightly with concentration of each. The number of 10 ppm of each IAA and IBA treated cuttings increased but many of the 100 ppm auxin treated ones decayed after 28 days. The number of 9-month old cuttings that rooted was higher with IBA treatment after 14 days but did not differ from the control after 28 days. This is because while the number increased in control, it did not with auxin application during the period 14-28 days. In 12-month old plantlets, the number of 100 ppm IAA and 10 ppm IBA treated cuttings that rooted was higher than the control after 14 days. The number increased after 28 days, the increase being more in control so that all the control and 100 ppm IAA treated cuttings rooted after 28 days. It may be noted that cuttings of this age group did not decay regardless of the treatment. This is in contrast to cuttings from younger plantlets, many of which decayed after 28 days particularly when treated with higher concentrations of auxins.

It is interesting to note that while 3-4 cuttings from 15-month old plants rooted after 14 days with auxin application, rooting occurred in control cuttings only after 28 days, the number of rooted cuttings being lower than with auxin application (Fig.23).
**Number of roots:** Fig. 24 shows that only a few roots were produced on 3-month old 10 ppm IAA and 10 and 100 ppm IBA-treated cuttings after 14 days but these decayed with time so that the number was lower after 28 than after 14 days. The control and 100 ppm IAA treated cuttings did not root at all.

In 6 month old cuttings, the number of roots increased with 100 ppm each of IAA and IBA after 14 days but many of the roots decayed after 28 days. In contrast to this, in control and 10 ppm of each IAA and IBA treated cuttings, the number of roots increased after 28 days, IAA being more effective than IBA.

In cuttings from 9-month old plantlets, the number of roots was higher than the control with IBA after 14 days, remaining low in other cases even after 28 days. In cuttings taken from 12-month old plantlets, the number was higher with 100 ppm each of IAA and IBA after 14 days and increased in all cases after 28 days except with 100 ppm IBA. However, the increase was more in control and 100 ppm IAA treated cuttings than in others.

In cuttings taken from 15-month old plants, a few roots emerged on auxin-treated cuttings after 14 days but their number increased after 28 days. Rooting occurred in control also after 28 days but their number was higher on auxin treated than on control cuttings (Fig. 24).

**Length of root:** Fig. 25 presenting the mean length of roots shows that the roots were produced (only) in control and 100 ppm IAA treated cuttings but these did not elongate much
even after 28 days in other cases. In cuttings taken from 6-month old plants, roots elongated more with auxin application than in control after 14 days, the effect increasing with concentration of each auxin. The elongation was more with 10 ppm each of IAA and IBA than in control after 28 days, 100 ppm of both auxins inhibiting root elongation. In cuttings from 9-month old plants, root elongation was more with IBA than in control after 14 days. Roots did not elongate much after 28 days except in control. In 12-month old cuttings, the roots were longer with auxin application than in control after 14 days and elongated further in all cases after 28 days, the increase in length being more in control than in other cases, so that the roots on control were longer than on auxin treated cuttings. In 15-month old plants, roots elongated more with auxin application, the effect of IAA increasing with concentration after 28 days (Fig. 25).

It may be noted that the number and length of roots on control cuttings increased with age till 12 months but was lower on 15 month than on 12-month old cuttings. The effect of auxins was, however, more marked on these than on younger cuttings.

(d) Auxin and GA Effects on Rooting under Varying Light Conditions.

Experiments 1–3 demonstrated that season exerted a marked effect on the rooting response of stem cuttings. The following experiments were carried out to investigate the extent to which seasonal changes in auxin effects on rooting could be
scribed to changes in the light and temperature conditions prevailing at different times during the annual growth cycle. Of these, experiments 4–9 were carried out to study the effect of photoperiod, experiments 10 and 11 the effect of light intensity, experiments 12–14 the effect of quality of light and experiments 15 and 16, the effect of temperature on rooting.

(1) Rooting in relation to photoperiod

Experiment 4: This experiment was designed to study the effect of photoperiod on the rooting response of stem cuttings of *Bryophyllum tubaeformis*.

Four hundred and fifty plantlets raised by sowing epiphyllous buds were divided into 3 lots of 30 pots each with 5 plants in each pot on April 11, 1966 to be exposed to SD, ND and LD conditions, respectively as described under 'Experimental Procedure' given on page 52. On October 11, 1966, 12.5 cm long stem cuttings from each lot were planted separately in earthenware pots containing 1:1 mixture of sand and farmyard manure and were divided into 3 groups each to be exposed to SD, ND and LD conditions, respectively. There were, therefore, 9 photoperiodic treatments (3 to mother plant x 3 to cuttings). Five cuttings from each treatment were removed at weekly intervals and observations were recorded on the number of cuttings rooted and the number and length of roots produced for 4 weeks.

Number of cuttings rooted: The results are presented in Table I. All stem cuttings from SD plants rooted under SD
<table>
<thead>
<tr>
<th>Number of rooted cuttings</th>
<th>Days after planting</th>
<th>Mean length of roots/cm</th>
<th>Photoperiod</th>
<th>Photoperiod</th>
<th>Photoperiod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>LA</td>
<td>SA</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>10</td>
<td>14</td>
<td>21</td>
<td>28</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Notes:
- LA: Long day
- SA: Short day
- ND: No day

Table 11: Rooting response of stem cuttings of SA, ND and LD-grown plants of *Eucalyptus urophylla* under different photoperiodic conditions. (Experiment 4)
and ND conditions after 14 days as compared to only 1
under LD conditions. The number of rooted cuttings increased
even under LD condition after 21 days when all of them rooted.
Roots were initiated on cuttings from ND grown plants after
14 days, the number of rooted cuttings being the highest
under SD and the lowest under LD conditions. All cuttings
even under LD condition rooted after 28 days. Roots emerged on 4 and 2 stem cuttings from LD grown plants
under SD and ND conditions, respectively after 14 days,
the number of rooted cuttings increasing with time in both
cases. Rooting did not occur at all on cuttings taken from
LD plants and exposed under LD conditions even till the
termination of the experiment after 28 days.

**Number of roots:** The number of roots produced on cuttings
from SD plants was higher under SD, less under ND and the
lowest under LD conditions. Stem cuttings taken from ND
grown plants also, showed more or less similar trends. Even
on stem cuttings taken from LD grown plants, the number of
roots was higher under SD than under ND conditions, there
being no roots at all under LD condition.

**Length of root:** The roots on cuttings from SD and ND
grown plants were longer than on cuttings taken from LD
plants. In the same lot, the roots were the longest on
cuttings exposed to SD condition and the shortest on those
exposed to LD condition. As stated earlier, cuttings taken
from LD plants and exposed to LD condition subsequently
did not root at all.
Experiment 5: Experiment 4 showed that long days were non-inductive for rooting *Bryophyllum tubiflorum* cuttings and that rooting increased with time when cuttings from SD plants were propagated under LD conditions. This experiment was designed to study the effect of varying numbers of SD and LD cycles given to the mother plant on the rooting response of cuttings subsequently exposed to SD and LD conditions.

Plantlets raised from epiphyllus buds sown on January 13, 1966 were divided into 2 lots on February 12, 1966 and were transferred to SD and LD conditions, respectively. Each lot was sub-divided into 4 groups to receive 10, 20, 40 and 80 LD cycles in the case of SD-grown plants and the same number of SD cycles in the case of LD-grown plants, respectively. Stem cuttings from each group were planted in pots and half were exposed to SD, and the other half to LD conditions subsequently.

Observations on the number of rooted cuttings and the number and length of roots were recorded at fortnight intervals and the results together with the treatments are presented in Table II.

\[ J_n \]

Number of cuttings rooted: in SD-grown plants, the number of rooted cuttings decreased with the increase in the number of LD cycles received by the mother plant regardless of whether the cuttings were exposed to SD or LD conditions subsequently, so much so that none of the cuttings taken from plants those had received 80 LD cycles rooted after
Table II: Rooting response of stem cuttings of *Bryophyllum tubiflorum* taken from plants receiving varying numbers of photoperiodic cycles and subsequently exposed to SD or LD conditions.

(Experiment 5)

<table>
<thead>
<tr>
<th>Photoperiod received by mother plant</th>
<th>Number of cycles of other photoperiod received by cuttings</th>
<th>Number of rooted cuttings</th>
<th>Number of roots per cutting</th>
<th>Mean length of root cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days after planting</td>
<td>14</td>
<td>28</td>
<td>Days after planting</td>
</tr>
<tr>
<td>10 LD</td>
<td>SD</td>
<td>10</td>
<td>10</td>
<td>4.5±0.84</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>9</td>
<td>10</td>
<td>1.4±0.32</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>10</td>
<td>10</td>
<td>3.2±0.68</td>
</tr>
<tr>
<td>20 LD</td>
<td>SD</td>
<td>8</td>
<td>10</td>
<td>1.3±0.36</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>3</td>
<td>10</td>
<td>0.5±0.04</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>2</td>
<td>10</td>
<td>0.5±0.05</td>
</tr>
<tr>
<td>40 LD</td>
<td>SD</td>
<td>0</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>80 LD</td>
<td>SD</td>
<td>8</td>
<td>8</td>
<td>1.2±0.20</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>7</td>
<td>10</td>
<td>1.4±0.34</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>8</td>
<td>9</td>
<td>1.4±0.60</td>
</tr>
<tr>
<td>20 SD</td>
<td>LD</td>
<td>8</td>
<td>10</td>
<td>1.8±0.36</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>10</td>
<td>10</td>
<td>3.1±0.60</td>
</tr>
<tr>
<td>40 SD</td>
<td>LD</td>
<td>10</td>
<td>10</td>
<td>2.2±0.60</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>10</td>
<td>10</td>
<td>3.8±0.48</td>
</tr>
<tr>
<td>80 SD</td>
<td>LD</td>
<td>9</td>
<td>10</td>
<td>2.1±0.18</td>
</tr>
</tbody>
</table>
14 days. The number of rooted cuttings increased with time in all cases and all cuttings from plants receiving up to 40 LD cycles rooted after 28 days. Even in 80 LD ones, 7 and 2 cuttings rooted under SD and LD conditions, respectively after 28 days.

In LD grown plants receiving varying numbers of SD cycles, the number of rooted cuttings did not differ much up to 20-SD cycles but increased with 40 and 80 SD cycles after 14 days, the photoperiod to which cuttings were exposed not affecting the number (Table II).

**Number of roots:** More roots were produced on cuttings taken from SD grown plants receiving varying numbers of LD cycles when exposed to SD than LD, the number of roots decreasing with the increasing number of LD cycles received by the mother plant. The number of roots increased in all cases after 28 days, being higher under SD than under LD conditions, although the increase during the period 14–28 days was more under LD condition. Even in the plants receiving 80 LD cycles, the number of roots was higher under SD than under LD condition (Table II).

In cuttings taken from LD-grown plants receiving 10 SD cycles, a few roots were initiated after 14 days both under SD and LD conditions but the increase after 28 days was more under LD condition. In plants receiving 20 SD cycles, the number of roots did not differ much under the two photoperiods and increased after 28 days. The number of roots on plants receiving 40- and 80-SD cycles was more
on cuttings exposed to SD than LD conditions after 14 days but it did not differ after 28 days, the number being higher on cuttings taken from plants receiving 80 than on those receiving 40 SD cycles.

Length of root: In both the lots of plants, roots were longer on cuttings subsequently exposed to LD than SD conditions and the length increased with time (Table II).

(ii) Auxin and GA₄ effects on rooting in relation to photoperiod

Experiment 61: This experiment was designed to study the effect of auxins and GA₄ on the rooting response of stem cuttings of Bryophyllum tubiflorum under varying photoperiodic conditions.

Seventy stem cuttings, each from SD and LD grown plants were divided into 7 groups. Group I was treated with water to serve as control, while groups 2–7 were treated with 10 and 100 ppm each of IAA and IBA and GA₄, respectively by dipping their basal portions in the respective solution for 24 hours. After the treatment, cuttings were planted in pots and were exposed to the photoperiod under which the respective mother plants were raised.

Observations were recorded after 28 days and the results along with the treatments are presented in Table III.

Number of cuttings rooted: It is seen that root initiation
Table III: Effect of IAA, IBA and GA<sub>3</sub> on rooting of stem cuttings of *Bryophyllum tubiflorum* grown under two photoperiods. (Experiment 6)

<table>
<thead>
<tr>
<th>Photoperiodic condition</th>
<th>Auxin treatments</th>
<th>Number of rooted cuttings</th>
<th>Number of roots per cutting</th>
<th>Mean length of root-cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD plants under SD conditions</td>
<td>Control</td>
<td>9</td>
<td>4.3±0.18</td>
<td>0.64±0.10</td>
</tr>
<tr>
<td>IAA, 10 ppm</td>
<td>10</td>
<td>9.8±2.90</td>
<td>1.24±0.28</td>
<td></td>
</tr>
<tr>
<td>IAA, 100 ppm</td>
<td>10</td>
<td>97.4±10.80</td>
<td>1.30±0.16</td>
<td></td>
</tr>
<tr>
<td>IBA, 10 ppm</td>
<td>10</td>
<td>18.2±1.20</td>
<td>2.39±0.59</td>
<td></td>
</tr>
<tr>
<td>IBA, 100 ppm</td>
<td>10</td>
<td>94.6±5.20</td>
<td>1.16±0.28</td>
<td></td>
</tr>
<tr>
<td>GA&lt;sub&gt;3&lt;/sub&gt;, 10 ppm</td>
<td>10</td>
<td>6.2±0.40</td>
<td>0.76±0.12</td>
<td></td>
</tr>
<tr>
<td>GA&lt;sub&gt;3&lt;/sub&gt;, 100 ppm</td>
<td>10</td>
<td>11.2±0.80</td>
<td>1.30±0.03</td>
<td></td>
</tr>
<tr>
<td>LD plants under LD conditions</td>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>IAA, 10 ppm</td>
<td>10</td>
<td>4.4±0.70</td>
<td>1.56±0.62</td>
<td></td>
</tr>
<tr>
<td>IAA, 100 ppm</td>
<td>10</td>
<td>33.2±7.10</td>
<td>2.28±0.23</td>
<td></td>
</tr>
<tr>
<td>IBA, 10 ppm</td>
<td>10</td>
<td>8.4±1.00</td>
<td>2.56±0.61</td>
<td></td>
</tr>
<tr>
<td>IBA, 100 ppm</td>
<td>10</td>
<td>45.8±2.30</td>
<td>1.62±0.10</td>
<td></td>
</tr>
<tr>
<td>GA&lt;sub&gt;3&lt;/sub&gt;, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>GA&lt;sub&gt;3&lt;/sub&gt;, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
occurred on all the control, auxin treated and \( \text{GA}_3 \) treated cuttings that were taken from SD grown plants and were subsequently exposed to SD condition. In stem cuttings taken from LD grown plants and subsequently exposed to LD condition, rooting occurred with the application of IAA and IBA only, none of the control and \( \text{GA}_3 \) treated cuttings rooting under this condition (Table III).

**Number of roots:** The number of roots produced increased with auxin application, being higher with higher concentration in each case and with a given concentration was higher under SD condition, \( \text{GA}_3 \) failed to induce rooting in cuttings of LD plants kept under LD condition although it increased the number of roots initiated on cuttings of SD plants under SD conditions. The enhancement was, however, less than with IAA or IBA (Table III).

**Length of root:** The roots on IAA and IBA treated cuttings were longer than on control ones under both the light conditions and for the same concentration of auxin under LD than under SD condition (Table III). It may be noted that an increase in the concentration caused an increase in root length with IAA but a decrease with IBA under both light conditions. In the case of \( \text{GA}_3 \), the roots were longer with higher than with lower concentration.

Experiments 4–6 dealt with the study of the effect of auxins and \( \text{GA}_3 \) in relation to photoperiod on the rooting response of the stem cuttings of *Eryophyllum tubiflorum*.

The following experiments were undertaken to study
the rooting response of stem cuttings of other two species, namely, *Dalbergia sissoo* and *Salacia malabarica* to auxin application under varying photoperiodic conditions.

**Experiment 7**: This experiment was conducted to study the rooting response of stem cuttings of *D. sissoo* and *S. malabarica* taken from mother plants grown under 3 different photoperiods and treated with auxins.

Seedlings were raised from seeds sown on June 23, 1966 under SD, ND and LD conditions, respectively. On September 23, 1966, stem cuttings, each 22 cm long, were taken from plants under these conditions separately and were divided into 5 equal groups each to receive auxin treatment as described in Experiment 1.

After the treatment, cuttings were planted in earthenware pots and were kept under natural conditions of photoperiod and temperature obtaining at Chandigarh (Fig.1). Observations were recorded at weekly intervals and are presented diagramatically in Figs.26-34 for *D. sissoo* and in Figs.35-43 for *S. malabarica*.

*Dalbergia sissoo*

**Number of cuttings rooted**: The number of cuttings taken from SD, ND and LD grown plants that rooted after 7, 14 and 21 days are shown in Figs.26-28, respectively. It is seen that stem cuttings from SD and ND grown plants rooted after 14 days with IBA but after 21 days in control and with IAA, the number of rooted cuttings increasing with time, so that
all of them rooted after 28 days except 8 out of 10 in control from SD grown plants (Fig. 26).

Stem cuttings from LD grown plants also rooted after 14 days with 10 ppm IBA, but after 21 days in all other cases, the number of rooted cuttings increasing with time and being higher with auxin application than in control. It may be noted that only 6 and 8 cuttings from LD grown plants rooted in control and with auxin application, respectively even after 28 days as compared to all 10 cuttings from SD and ND grown plants (Figs. 26–28).

**Number of roots:** The number of roots produced per cutting from SD, ND and LD grown plants, is shown in Figs. 29–31, respectively. A few roots emerged on IBA treated cuttings taken from SD plants after 14 days, the number being higher with 100 than 10 ppm IBA. In control and IAA treated cuttings, the roots were initiated after 21 days and the number of roots increased with time, being higher with auxin application than in control and the effect of auxins increasing with concentration so that the number was the highest on 100 ppm IAA and decreased in order on 100 ppm IBA, 10 ppm IBA, 10 ppm IAA treated and control cuttings after 28 days.

In ND grown plants also cuttings rooted with IBA after 14 days although the number was lower than on cuttings taken from SD plants with same treatment. In control and IAA treated cuttings, roots emerged after 21 days but the number was the highest with 100 ppm IBA. The number increased
with time, the increase being more pronounced with 100 ppm IAA and 10 ppm IBA (Fig. 30).

In LD grown plants, a few roots appeared on 10 ppm IBA treated cuttings after 14 days. In all other cases, the roots emerged after 21 days, although the number of roots was lower than on cuttings from ND plants with 100 ppm each of IAA and IBA and not differing much in control and with 10 ppm each of IAA and IBA (Fig. 31).

Length of roots: The root length increased with time in all cases, roots being longer with auxin application than in control, the effect of auxin being more with 10 ppm than with 100 ppm on cuttings from SD and LD grown plants but with 100 ppm on those taken from ND-grown plants (Figs. 32-34).

Salmalia malabarica

Number of cuttings rooted: The rooting response of cuttings of Salmalia malabarica taken from SD, ND and LD grown plants is presented in Figs. 35-37, respectively. Rooting occurred in control and 100 ppm IBA treated cuttings taken from SD plants after 21 days, the number of rooted cuttings being higher with 100 ppm IBA. In 10 and 100 ppm IAA and 10 ppm IBA treated cuttings roots emerged after 28 days and the number of rooted cuttings did not differ much from the control, although it was much higher with 100 ppm IBA.

Only 2 control cuttings from ND plants rooted after 21 days. Auxins treated cuttings rooted after 28 days
and the number of rooted cuttings did not differ from the control except with 100 ppm IBA where roots emerged on only 2 out of 10 cuttings (Fig.36).

The control and IBA treated cuttings from LD grown plants rooted after 21 days, the number being higher in the latter. IAA treated cuttings rooted after 28 days, the number that rooted being less with 100 ppm IAA than in control or 10 ppm IAA (Fig.37).

**Number of roots:** Only a few roots were produced on control and 100 ppm IBA treated cuttings from SD plants after 21 days and the number did not increase much after 28 days. A few roots were produced on IAA treated cuttings after 28 days (Fig.38).

The number of roots produced on cuttings from ND plants was lower than on cuttings from SD ones (Fig.39).

As on cuttings from SD plants, roots on control and IBA treated cuttings from LD grown plants were also produced after 21 days and on IAA treated ones after 28 days (Fig.40).

**Length of root:** Roots on 100 ppm IBA treated cuttings from SD plants were longer but on 10 and 100 ppm IAA and 10 ppm IBA treated ones were shorter than on control cuttings (Fig.41).

Roots on auxin treated cuttings from ND plants were produced after 28 days and were longer than on control where roots were produced after 21 days (Fig.42).

Roots on cuttings from LD plants, appeared after
21 days on control and with IBA and were longer than in the latter (Fig. 43).

**Experiment 81**: The previous experiment was carried out to study the effect of photoperiod to which mother plants were exposed on the rooting of cuttings taken from them and subsequently planted under natural conditions of temperature and photoperiod. This experiment was designed to study the effect of auxins on rooting of stem cuttings taken from seedlings grown under natural conditions but subsequently exposed to varying photoperiods.

Seeds of *Delberonia sissoo* and *Salmalia malabarica* were sown on August 10, 1966 under natural conditions of temperature and photoperiod obtaining at Chandigarh. On November 10, 1966, when the seedlings were 3-month old, stem cuttings were taken and were divided into 5 groups. Group 1 was treated with water to serve as control while groups 2-5 were treated with 10 and 100 ppm each of IAA and IBA, respectively. After the treatment, the cuttings were planted in earthenware pots and each group was divided into 3 sub-groups to receive SD, ND and LD conditions, respectively. The results are presented in Figs. 44 to 52 for *D. sissoo* and in Figs. 53 to 61 for *S. malabarica*, respectively.

*Delberonia sissoo*

**Number of cuttings rooted**: Figs. 44–46 show that roots were initiated on 100 ppm IAA and 10 and 100 ppm IBA
Number of roots: Under SD condition, a few roots were initiated on 100 ppm each of IAA and IBA treated cuttings after 28 days. In control and 10 ppm treated ones, rooting occurred after 42 days, the number of roots being higher with auxin application and increasing with their concentration (Fig.47).

Under ND condition, roots in all cases appeared after 56 days only and the number of roots was higher with 100 ppm IAA than in control or with 100 ppm IBA (Fig.48).

Under LD condition stem cuttings did not root at all till the termination of the experiment after 56 days (Fig.49).

Length of root: The roots on stem cuttings under SD condition were longer than under ND condition (Figs.50-52).
Salmalia malabarica

**Number of cuttings rooted:** Under SD condition, 2 control and 4,100 ppm IAA and IBA treated cuttings rooted after 28 days, the number increasing to 4 after 42 days in control and 6 in 100 ppm IBA treated cuttings after 56 days, and not changing in other cases. Two of the 10 ppm IBA treated cuttings also rooted after 56 days (Fig.53).

Under ND condition only 2 cuttings rooted with 10 ppm IBA after 56 days (Fig.54), and under LD condition cuttings did not root even with auxin application (Fig.55).

**Number of roots:** The trends of results of the number of roots (Figs. 56-58) were more or less similar to the number of cuttings that rooted (Figs. 53-55).

**Length of root:** Under SD condition, the roots on 100 ppm IAA and IBA treated cuttings elongated more than the control. Rooting on 10 ppm IBA treated cuttings was delayed and the roots were very short (Fig.59).

As has already been stated under ND condition, roots were produced on 10 ppm IBA treated cuttings only and were very short (Fig. 60) and under LD condition there was no rooting at all (Fig.61).

**Experiment 2:** In the previous experiment, it was observed that rooting was earlier and the number of roots higher under SD than under ND conditions; there being no rooting at all under LD condition even when the experiment was terminated after 56 days. The seedlings in that experiment
Table IV: Rooting response of stem cuttings of *Dalbergia sissoo* after auxin treatment under different photoperiodic conditions. (Experiment 9)

<table>
<thead>
<tr>
<th>Photoperiod received by cuttings</th>
<th>Auxin treatment</th>
<th>Number of rooted cuttings Days after planting</th>
<th>Number of roots per cutting Days after planting</th>
<th>Mean length of root-cm Days after planting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>14 28</td>
<td>14 28</td>
<td>14 28</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>8 7</td>
<td>6.0±0.22</td>
<td>5.3±0.15</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>10 7</td>
<td>11.4±0.62</td>
<td>7.4±0.28</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>8 9</td>
<td>2.6±0.81</td>
<td>8.0±0.18</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>10 7</td>
<td>3.6±0.29</td>
<td>8.4±2.22</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>8 3</td>
<td>6.0±0.38</td>
<td>5.4±1.35</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>4 3</td>
<td>2.0±0.80</td>
<td>4.5±0.26</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>6 8</td>
<td>2.0±0.60</td>
<td>9.0±1.12</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>6 1</td>
<td>5.4±0.21</td>
<td>1.2±1.00</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>6 8</td>
<td>2.6±0.80</td>
<td>4.7±0.12</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>8 1</td>
<td>3.8±0.21</td>
<td>0.7±0.60</td>
</tr>
<tr>
<td>ND</td>
<td></td>
<td>8 9</td>
<td>3.2±0.28</td>
<td>9.5±0.19</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>8 7</td>
<td>11.2±0.20</td>
<td>13.2±0.32</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>4 9</td>
<td>7.0±0.40</td>
<td>5.9±0.11</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>10 7</td>
<td>6.0±0.90</td>
<td>7.2±0.77</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>6 6</td>
<td>10.4±1.80</td>
<td>14.9±0.31</td>
</tr>
</tbody>
</table>
were raised during August to November and rooting trials were conducted during November to January when the natural day length and daily temperature were gradually decreasing. In order to see if the daily photoperiod and temperature to which the mother plants were exposed and also temperature conditions to which the cuttings were subjected had some effect on rooting, another experiment was designed. In this experiment, the seedlings were raised during April to July and rooting trials were conducted during July to August when the temperature was higher and days longer.

Seeds of *Dalbergia sissoo* and *Salmalia malabarica* were sown on April 13, 1967 under natural conditions of temperature and photoperiod. On July 13, 1967, stem cuttings were treated with 10 and 100 ppm of IAA and IBA, and were exposed to SD, ND and LD conditions, respectively as in Experiment 8. The results of number of rooted cuttings and number and length of roots are presented in Tables IV and V for *D. sissoo* and *S. malabarica*, respectively.

*Dalbergia sissoo*

**Number of cuttings rooted:** Under SD, the number of control and 100 ppm IAA and IBA treated cuttings that rooted was 8 as compared to 10 with 10 ppm each of IAA and IBA after 14 days. The number of rooted cuttings did not change much in control and with IAA but decreased with IBA after 28 days, due to the decay of cuttings, the effect increasing with concentration (Table IV).

Under ND condition, rooting occurred after 14 days,
the number of rooted cuttings being higher with auxin application, than in control, 100 ppm IBA being most effective. It is interesting to note that while the number of rooted cuttings did not change much in control, it increased with both 10 ppm IAA and IBA after 28 days. However, most of the cuttings treated with either 100 ppm IAA or 100 ppm IBA decayed after 28 days (Table IV).

Under LD condition, 8 control cuttings rooted after 14 days, the number being higher with 10 ppm IBA but lower with 100 ppm of both IAA and IBA. It may also be noted that under this condition there was no decay of cuttings and the number that rooted increased with 100 ppm IAA after 28 days but did not change much in other cases (Table IV).

**Number of roots:** Under SD condition, the number of roots produced was higher with 10 ppm IAA but lower than the control in other cases after 14 days. It increased with 100 ppm IAA and 10 ppm IBA but not in other cases after 28 days and as a consequence of which it was higher than the control in auxin-treated cuttings except in 100 ppm IBA treated ones in which the number did not differ from the control.

Under ND condition, the number of roots was higher with auxin application than in control after 14 days, the effect increasing with concentration. While the number increased in control and 10 ppm IAA and IBA treated cuttings after 28 days, the effect of IAA being more pronounced, it
decreased in 100 ppm IAA or IBA treated ones, due to the decay of roots (Table IV).

Under LD condition, the number of roots was higher with auxin application than in control after 14 days, the effect increasing with concentration of IBA and decreasing with that of IAA. The number of roots increased in all cases after 28 days except with 100 ppm IAA, the increase being more pronounced in control (Table IV).

Length of root: Under SD condition, the roots on 10 ppm IAA treated cuttings were longer than the control after 14 days. A pronounced decrease in root length was observed on 10 ppm IAA and 100 ppm IBA treated cuttings probably because of their decay after 28 days and as a consequence of which roots on 100 ppm IBA treated cuttings were considerably shorter than on control, the length not varying significantly in other cases.

Under ND condition, the roots did not elongate much after 14 days and were longer with 10 ppm but shorter than the control with 100 ppm IBA after 28 days, the length in other cases not varying significantly from the control.

Under LD condition, root length did not differ much from the control with auxin application after 14 days, except with 100 ppm IAA which inhibited root elongation. The inhibitory effect of auxins on root elongation was clearly observed after 28 days, the effect being more pronounced with IBA than with IAA (Table IV).

Salmalia malabarica

Number of cuttings rooted: The rooting response of cuttings
Table V: Rooting response of stem cuttings of *Salvia malabarica* after auxin treatment under different photoperiodic conditions.

(Experiment 9)

<table>
<thead>
<tr>
<th>Photoperiod received by cuttings</th>
<th>Auxin treatment</th>
<th>Number of rooted cuttings Days after planting</th>
<th>Number of roots per cutting Days after planting</th>
<th>Mean length of root-cm Days after planting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>4</td>
<td>4</td>
<td>0.5 ± 0.20</td>
</tr>
<tr>
<td>IAA, 10 ppm</td>
<td></td>
<td>2</td>
<td>3</td>
<td>0.5 ± 0.20</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>3</td>
<td>3</td>
<td>0.6 ± 0.22</td>
</tr>
<tr>
<td>IAA, 100 ppm</td>
<td></td>
<td>4</td>
<td>5</td>
<td>0.8 ± 0.17</td>
</tr>
<tr>
<td>IBA, 10 ppm</td>
<td></td>
<td>4</td>
<td>0</td>
<td>0.6 ± 0.18</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>4</td>
<td>4</td>
<td>0.7 ± 0.22</td>
</tr>
<tr>
<td>IAA, 10 ppm</td>
<td></td>
<td>4</td>
<td>2</td>
<td>0.8 ± 0.17</td>
</tr>
<tr>
<td>ND</td>
<td></td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>IBA, 10 ppm</td>
<td></td>
<td>6</td>
<td>4</td>
<td>1.1 ± 0.32</td>
</tr>
<tr>
<td>IBA, 100 ppm</td>
<td></td>
<td>4</td>
<td>0</td>
<td>0.6 ± 0.19</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>5</td>
<td>4</td>
<td>0.9 ± 0.12</td>
</tr>
<tr>
<td>IAA, 10 ppm</td>
<td></td>
<td>2</td>
<td>4</td>
<td>0.2 ± 0.12</td>
</tr>
<tr>
<td>LD</td>
<td></td>
<td>3</td>
<td>2</td>
<td>0.5 ± 0.23</td>
</tr>
<tr>
<td>IBA, 10 ppm</td>
<td></td>
<td>4</td>
<td>6</td>
<td>0.6 ± 0.20</td>
</tr>
<tr>
<td>IBA, 100 ppm</td>
<td></td>
<td>3</td>
<td>3</td>
<td>0.4 ± 0.18</td>
</tr>
</tbody>
</table>
of S. malabarica is shown in Table V.

Under SD and ND conditions, the number of rooted cuttings did not differ from the control with auxin application except that all cuttings treated with 100 ppm IBA decayed after 28 days. Even under LD condition, the number of rooted cuttings with 100 ppm IAA and IBA was lower than in control (Table V).

**Number of roots**: Only a few roots were produced on each cutting and the number with auxin application did not differ significantly from the control (Table V).

**Length of root**: Under SD, the roots on 10 ppm IAA treated cuttings were slightly longer than the control, but these were shorter in other treatments. Under ND and LD conditions, roots were shorter than the control in all cases (Table V).

(iii) Rooting in relation to light intensity

It is seen in Experiments 4 to 9 that photoperiod has a profound effect on rooting of stem cuttings. It was considered interesting to study the effect of intensity and quality of light on rooting of cuttings of these species and the following experiments were carried out:

**Experiment 10**: This experiment relates to the effect of light intensity received by the mother plant and the cuttings taken from them, on the rooting response of Bryophyllum tubiflorum.

Plantlets of B. tubiflorum raised under natural day light for a month, were divided into 3 lots to receive
light of 15,000; 1,000 and 100 ft c., respectively for 4 months during March-June, 1957. One hundred and twenty stem cuttings from each lot were divided into 3 groups of 40 each. While one group in each case was exposed to the same light intensity as was received by the mother plant, the other two were exposed to the other two intensities of light. There were, therefore, 9 treatment combinations (3 to mother plants x 3 to cuttings). Ten cuttings from each treatment were taken out at 14 day intervals for observations on rooting behaviour.

**Number of cuttings rooted:** The results presented in Fig.62 show that the number of rooted cuttings from plants grown under 15,000 ft c. decreased while those from 1,000 and 100 ft. c. increased with the decrease in the intensity of light after 14 days. Even on cuttings taken from 15,000 ft c. the differences levelled off more or less completely after 28 days, all cuttings rooting in all cases (Fig.62).

**Number of roots:** The trends of results of number of roots (Fig.63) were similar to those of the number of rooted cuttings (Fig.62) after 14 days, although the effects of light intensity on cuttings taken from plants under 1,000 and 100 ft c. were more pronounced. It is interesting to note that although the number of roots increased with time in all cases, the trends remained more or less the same and that the roots produced on cuttings taken from plants grown under 1,000 and 100 ft. c. were very thin and slender,
while those on cuttings from 15,000 ft c. were normal.

Length of root: The trends of results of root length (Fig. 64) were similar to those of the number of roots (Fig. 63), the length decreasing on cuttings taken from 15,000 ft c. and increasing on those from 1,000 and 100 ft c. grown plants after 14 days. However, these differences disappeared after 28 days except in cuttings taken from plants grown under 15,000 ft c. and exposed to the same light intensity, where roots elongated considerably more than under other conditions.

(iv) Auxin effects on rooting in relation to light intensity

Experiment II: This experiment was carried out to study the effect of auxins on rooting stem cuttings of Bryophyllum tubiflorum, Dalbergia sissoo and Salmalia malabarica under 3 intensities of light.

One hundred and fifty stem cuttings were obtained from 6-month old plants grown in sunlight (15,000 ft c.). These were divided into 5 equal groups to receive auxin treatments as described in Experiment I on page 62. After the treatment cuttings were planted in pots and were further, divided into three sub-groups to receive light of 15,000, 1,000 and 100 ft c. intensity, respectively.

Observations on rooting were recorded after 28 days and the results are presented in Figs. 65–67 for B. tubiflorum in Figs. 68–70 for D. sissoo and in Figs. 71–73 for S. malabarica.
Bryophyllum tubiflorum

Number of cuttings rooted: Fig. 65 shows that all the control cuttings rooted under all light intensities. The number of rooted cuttings was lower with 100 ppm of each IAA and IBA under 1,000 and 100 ft c. light, the inhibitory effect of IBA being more under 100 ft c. so that only 4 out of 10 cuttings rooted under this condition.

Number of roots: Auxins enhanced the number of roots, the effect in each case decreasing with the intensity of light (Fig. 66). The effectiveness of auxins increased with concentration under 15,000 ft c., the concentration effect being more pronounced with IAA. Under 1,000 and 100 ft c., the number of roots was higher than the control with 100 ppm IAA and 10 and 100 ppm IBA, the effectiveness of IBA decreasing with concentration (Fig. 66).

Length of root: Roots on cuttings exposed to 15,000 ft c. were the longest and on those exposed to 1,000 ft c. the shortest (Fig. 67). The length of roots decreased with auxin application, the decrease being most pronounced under 15,000 ft c., less under 1,000 and not much under 100 ft c. (Fig. 67).

Calathea siamica

Number of cuttings rooted: The results presented in Fig. 68 show that the number of cuttings that rooted under 1,000 and 100 ft c. was higher than that under 15,000 ft c. light intensity. Thus, while all the control cuttings rooted under 1,000 and 100 ft c., only 2 out of 10 rooted under 15,000 ft c. The effect of
auxins also varied considerably with the light intensity. The number of rooted cuttings was lower than the control with auxin application under 1,000 and 100 ft c., the inhibition effect increasing considerably with concentration of each IAA and IBA. Under 15,000 ft c., the auxins did not affect the number of rooted cuttings except with 10 ppm IBA which increased the number slightly (Fig. 68).

**Number of roots:** The number of roots on control cuttings increased with the decrease in the intensity of light, being the highest under 100 ft c. but was lower than the control with auxin application in cuttings under 1000 and 100 ft c., the inhibitory effect being more pronounced with 100 ppm of both IAA and IBA under 100 ft c. but with 100 ppm IBA under 1,000 ft c. Under 15,000 ft c., the number of roots increased with 100 ppm of both IAA and IBA, the former being more effective (Fig. 69).

**Length of root:** Roots on cuttings exposed to 1,000 and 100 ft c. light intensity were longer than those on cuttings under 15,000 ft c. (Fig. 70). The elongation of roots was inhibited with auxin application under all light intensities except with 10 ppm IAA under 15,000 ft c. where roots elongated as much as in control. Again it may be noted that both 100 ppm IAA and IBA inhibited root elongation more than 10 ppm under 1,000 and 100 ft c.

*Salmalia malabarica*

**Number of cuttings rooted:** The number of control cuttings
that rooted increased with the decreasing light intensity (Fig. 71) and was lower than the control with auxin application under each light intensity, the inhibitory effect of auxins being most pronounced under 100 ft c. and the least under 15,000 ft c. light (Fig. 71).

**Number of roots:** The number of roots produced on control under 1,000 ft c. light was higher than those produced under 15,000 and 100 ft c. light. Auxins decreased the number of roots, IAA being more effective than IBA under each light condition (Fig. 72).

**Length of root:** The length of roots (Fig. 73) showed trends similar to those shown by the number of roots (Fig. 72). Thus, the roots on control cuttings were longer under 1,000 and 100 ft c. than under 15,000 ft c. light and auxins inhibited their growth, the inhibitory effect being most pronounced under 100 ft c. light (Fig. 73).

V. Rooting in relation to light quality

**Experiment 12:** This experiment was designed to study the effect of quality of light on rooting of stem cuttings of *Bryophyllum tubiferum*.

One hundred and twenty stem cuttings taken from 6-month old plants were divided into 6 groups. Groups 1 and 2 were exposed to white light of 100 and 30 ft c. intensity, respectively; while groups 3–6 were exposed to blue, green, yellow and red light each of 30 ft c. intensity, respectively.

Observations on the rooting response of cuttings were
taken at fortnightly intervals and the results are presented in Figs. 74-76.

**Number of cuttings rooted:** The results presented in Fig. 74 show that rooting occurred on all cuttings exposed to 100 ft c. white light. The number of rooted cuttings was appreciably lower under 30 ft c. white light, but increased in the order under blue, green, yellow and red monochromatic lights so much so under red light, all cuttings rooted even after 14 days. In other cases, the number of rooted cuttings increased slightly after 28 days.

**Number of roots:** The results of number of roots (Fig. 75) showed trends similar to those of the number of rooted cuttings (Fig. 74). Thus, the number of roots under 100 ft c. white and 30 ft c. red lights did not differ between themselves but was higher than that under yellow, green or blue lights after 14 days. The number increased in all cases after 28 days, the increase being more marked under 100 ft c. white light (Fig. 75).

**Length of root:** Roots elongated more under 100 ft c. white and 30 ft c. red light than under other lights after 14 days and the length increased after 28 days on cuttings under 100 ft c. white light but did not under other light conditions (Fig. 76).

VI. **Auxin effects on rooting in relation to light quality:**

Experiment 12 showed that the quality of light also has a profound influence on rooting of stem cuttings. It
was considered interesting to study if the effectiveness of exogenously applied auxins in rooting was also influenced by the quality of light to which stem cuttings were exposed. Two experiments were, therefore, designed: Experiment 13 to study the response of *Bryophyllum tubiflorum* and Experiment 14 the response of *Delbergia stason* and *Salmalia malabarica*.

**Experiment 13:** Two hundred and fifty stem cuttings of *Bryophyllum tubiflorum* obtained from 6-month old plants were divided into 5 lots to receive auxin treatment as described earlier. These were planted in pots and each lot was further divided into 5 groups to be exposed to white, blue, green, yellow and red lights, respectively.

Observations were recorded after 28 days and the results are presented diagrammatically in Figs. 77-79.

**Number of cuttings rooted:** It is observed that all the control as well as 10 ppm of each IAA and IBA treated cuttings rooted regardless of the quality of light to which these were exposed (Fig. 77). The number of 100 ppm IBA treated cuttings that rooted was lower than the control, the effect being more marked under green and yellow lights and most marked under red light where none of the cuttings rooted at all. The number of 100 ppm IAA treated cuttings that rooted was also lower than the control under green light (Fig. 77).

**Number of roots:** The results presented in Fig. 78 demonstrate that the number of roots on control cuttings did not differ much with the quality of light. The number increased with
IAA, the effect being more pronounced with 100 than with 10 ppm. IBA in low concentration did not affect the number of roots appreciably but in higher concentration reduced it under all light conditions except under blue light where it did not differ much from the control (Fig.78).

Length of root: The roots on control cuttings were the longest under green light, slightly less under the yellow and the shortest under white light. The elongation of roots was enhanced by both IAA and IBA under white light, the effect being more pronounced with 10 than with 100 ppm in each case. Under blue and green lights, auxins inhibited root elongation, the inhibitory effect being most pronounced with 100 ppm IBA. Under yellow light also, auxins inhibited root elongation except 10 ppm IBA which did not affect it. Under red light while IAA did not affect root length IBA decreased it, no roots being produced with 100 ppm IBA (Fig.79).

Experiment 14: This experiment deals with the effect of auxins on rooting of stem cuttings of *Dalbercia sissoco* and *Salmalia malabarica* exposed to white, red and blue lights. Other details of experimentation were similar to those described in Experiment 13. The results are given in Figs. 80-82 for *Dalbercia sissoco* and in Figs.83-85 for *Salmalia malabarica*.

**Dalbercia sissoco**

Number of cuttings rooted: The results presented in Fig.80 show that the number of control cuttings that rooted was 9 under white as compared to 8 and 7 under red and blue lights,
respectively. Auxins did not affect the number of rooted cuttings under white and red lights but increased it slightly under blue light.

**Number of roots:** The number of roots was higher with auxin application than in control under all light conditions, 100 ppm IAA being more effective under white light and both 100 ppm IAA and IBA under red and blue lights (Fig. 81).

**Length of root:** The length of roots on control cuttings did not differ much with the quality of light (Fig. 82). Auxin enhanced root elongation under all light conditions, both concentrations of IBA being more effective under white light, 10 ppm IBA and 100 ppm IAA under red and both concentrations of both auxins under blue light (Fig. 82).

*Salmalia malabarica*

**Number of cuttings rooted:** Fig. 83 shows that only 2-3 control cuttings rooted under all light conditions. The number of rooted cuttings decreased with auxin application under white and red lights, there being no rooting at all with 100 ppm IBA; but increased considerably under blue light, except with 10 ppm IAA which decreased it (Fig. 83).

**Number of roots:** The roots produced on control cuttings under all light conditions were few and decreased further with auxin application under white and red lights but increased appreciably under blue light except with 10 ppm IAA (Fig. 84).

**Length of root:** The roots on control cuttings were longer under
Table VI: Effect of auxins on the rooting response of stem cuttings of *Bryophyllum tubiflorum* at different temperatures.

(Experiment 15)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Auxin treatment</th>
<th>Number of rooted cuttings</th>
<th>Number of roots per cutting</th>
<th>Mean length of root-cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Days after planting</td>
<td>Days after planting</td>
<td>Days after planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>35°C</td>
<td>Control</td>
<td>9</td>
<td>5</td>
<td>4.5±1.60</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>10</td>
<td>4</td>
<td>9.6±0.16</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>10</td>
<td>2</td>
<td>18.3±1.80</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>10</td>
<td>2</td>
<td>6.3±0.40</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>8</td>
<td>0</td>
<td>15.4±1.60</td>
</tr>
<tr>
<td>25°C</td>
<td>Control</td>
<td>10</td>
<td>7</td>
<td>4.6±0.35</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>10</td>
<td>5</td>
<td>5.7±0.42</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>10</td>
<td>3</td>
<td>12.6±0.80</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>10</td>
<td>7</td>
<td>9.2±1.60</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>8</td>
<td>0</td>
<td>7.8±2.10</td>
</tr>
<tr>
<td>15°C</td>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
white than under red and blue lights. Auxins inhibited root elongation under white and red lights except with 10 ppm IBA in the latter. However, under blue light roots were much longer with auxin application than in control, root length with 10 ppm IAA not differing from the control (Fig.85).

VII. Auxin effects on rooting in relation to temperature

The following experiments were carried out to study the effect of auxins on rooting of stem cuttings at different temperatures.

Experiment 15: Three hundred stem cuttings of Bryophyllum jubiflorum were obtained from 6-month old plants on June 20, 1967, and were divided into 5 lots to receive auxin treatment as described previously.

After auxin treatment, these were planted in plastic pots (9 cm dia.) and each lot was sub-divided into 3 groups and transferred to (i) 35°C, (ii) 25°C and (iii) 15°C, respectively with 8 hour photoperiod at 100 ft c.

Observations were recorded after 14 and 28 days.

Number of cuttings rooted: The results are presented in Table VI. Each figure in this table is a mean of 10 observations. It is seen that no rooting occurred on cuttings exposed to 15°C even with auxin application till the termination of the experiment after 28 days. After 14 days, 9 control cuttings rooted at 35° as compared to 10 at 25°C. All auxin-treated cuttings also rooted except 8 with 100 ppm IBA, at both 25° and 35°C. The number of rooted cuttings decreased
after 28 days due to the decay of some cuttings, the effect being more pronounced at 35°C. It may also be noted that higher number of cuttings decayed with auxin application than in the control, the effect increasing with concentration.

**Number of roots:** The number of roots produced on control cuttings did not differ much with temperature (Table VI). The number increased with auxin application at 35°C, being higher with higher concentration of auxins after 14 days. At 25°C, though the number of roots was higher with 100 than with 10 ppm IAA, it was higher with 10 than with 100 ppm IBA. It may be noted that the number of roots produced on cuttings at 35°C was higher than at 25°C in the corresponding treatments after 14 days. However, they decreased considerably due to the decay of roots after 28 days, the decrease being more pronounced at 35°C than at 25°C.

**Length of root:** The trends of results of the length of roots were more or less similar to the number of roots (Table VI) so that roots under the respective treatment were longer at 35°C than at 25°C and were longer with auxin application than in control.

**Experiment 16:** This experiment was carried out to confirm the findings of the previous experiment with *Bryophyllum tubiflorum* and to extend the studies of auxin effects on rooting in relation to temperature to the other species, namely, *Dalbercia sissoo* and *Salmalia malabarica*.

Three hundred cuttings each of *B. tubiflorum*, *D. sissoo*
Table VII: Effect of auxins on the rooting response of stem cuttings of *Bryophyllum tubiflorum* at different temperatures.
(Experiment 16)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Auxin treatment</th>
<th>Number of rooted cuttings</th>
<th>Number of roots per cutting</th>
<th>Mean length of root-cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Days after planting</td>
<td>Days after planting</td>
<td>Days after planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>10</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>10</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>35°C</td>
<td>Control</td>
<td>10</td>
<td>10</td>
<td>4.0±0.50</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>10</td>
<td>10</td>
<td>6.4±0.41</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>10</td>
<td>10</td>
<td>48.6±3.80</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>10</td>
<td>10</td>
<td>28.6±1.00</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>10</td>
<td>10</td>
<td>48.6±4.20</td>
</tr>
<tr>
<td>25°C</td>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15°C</td>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
and *S. malabarica* were treated with auxins on November 18, 1967, July 17, 1967 and August 16, 1967 respectively and were kept for rooting at 15°, 25° and 35°C as in Experiment 15. The results are presented in Tables VII, VIII and IX for *E. tubiflorum*, *D. sissoo* and *S. malabarica*, respectively.

**Eryophyllum tubiflorum**

**Number of cuttings rooted:** Table VII shows that as in the previous experiment, cuttings exposed to 15°C did not root even with auxin application, while all cuttings exposed to 35° and 25°C rooted after 14 days. A few of the 100 ppm auxin treated cuttings exposed to 35°C decayed after 26 days.

**Number of roots:** The number of roots produced on control cuttings was slightly higher at 25° than at 35°C after 14 days. The number was higher than the control on auxin treated cuttings at both temperatures, the effect increasing with concentration and being more pronounced with IBA than with IAA. At 25°C, the number of roots on control, 10 ppm IAA and 100 ppm IBA treated cuttings increased after 28 days. A marked decrease in the number, however, was observed at 35°C on 100 ppm IBA treated cuttings after 28 days probably due to the decay of roots at this high temperature. It may be noted that the number of roots with a given treatment was higher at 25° than at 35°C after 28 days (Table VII).

**Length of roots:** The length of roots on control cuttings did not differ much with temperature. Roots on 10 ppm IAA and IBA treated cuttings were longer, but on 100 ppm
Table VIII: Effect of auxins on the rooting response of stem cuttings of *Dalia* *sison* at different temperatures.

(Experiment 16)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Auxin treatment</th>
<th>Number of rooted cuttings</th>
<th>Number of roots per cutting</th>
<th>Mean length of roots cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Days after planting</td>
<td>Days after planting</td>
<td>Days after planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>35°C</td>
<td>Control</td>
<td>8</td>
<td>10</td>
<td>3.0±0.60</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>8</td>
<td>10</td>
<td>4.0±0.91</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>8</td>
<td>10</td>
<td>18.0±2.00</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>8</td>
<td>10</td>
<td>4.6±0.80</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>10</td>
<td>10</td>
<td>15.4±0.57</td>
</tr>
<tr>
<td>25°C</td>
<td>Control</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>6</td>
<td>8</td>
<td>5.6±2.10</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>6</td>
<td>7</td>
<td>3.8±1.30</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>6</td>
<td>6</td>
<td>2.4±1.00</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>8</td>
<td>9</td>
<td>6.0±1.20</td>
</tr>
<tr>
<td>15°C</td>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>OAA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
than control

treated ones were shorter both at 25°C and 35°C. Roots did not elongate at 35°C but elongated at 25°C after 26 days (Table VII).

Dalbergia sissoo

Number of cuttings rooted: As in R. tubiflorum, here also cuttings did not root at 15°C in spite of auxin application (Table VIII). Rooting did not occur in control cuttings even at 25°C after 14 days and only 3 cuttings rooted after 28 days. In marked contrast to this 6 out of 10 control cuttings rooted at 35°C after 14 days. It is interesting to note that with auxin application 6-6 cuttings rooted even at 25°C after 14 days and the number increased slightly after 28 days. At 35°C there was practically no difference between the number of control and auxin treated cuttings that rooted.

Number of roots: At 35°C, the number of roots increased with auxin application, the effect increasing with concentration. There was slight increase in the number of roots on control cuttings after 28 days but very little with auxin application. At 25°C also, the number of roots increased with auxin application, the effect increasing with concentration of each. It may be noted that the number of roots in the respective treatments was higher at 35°C than at 25°C. This is in marked contrast to R. tubiflorum where the number was higher at 25°C than at 35°C (Table VIII).

Length of root: The length of roots tended to decrease
Table IX: Effect of auxins on the rooting response of stem cuttings of *Salvia malabarica* at different temperatures.

(Experiment 16)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Auxin treatment</th>
<th>Number of rooted cuttings Days after planting</th>
<th>Number of roots per cutting Days after planting</th>
<th>Mean length of root cm Days after planting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>35°C</td>
<td>Control</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>4</td>
<td>6</td>
<td>0.4±0.15</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>2</td>
<td>8</td>
<td>0.4±0.25</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>2</td>
<td>2</td>
<td>0.2±0.12</td>
</tr>
<tr>
<td>25°C</td>
<td>Control</td>
<td>2</td>
<td>4</td>
<td>0.2±0.12</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>2</td>
<td>4</td>
<td>0.2±0.12</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>2</td>
<td>2</td>
<td>0.4±0.25</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>4</td>
<td>6</td>
<td>0.6±0.10</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>4</td>
<td>3</td>
<td>0.2±0.11</td>
</tr>
<tr>
<td>15°C</td>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IAA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 10 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IBA, 100 ppm</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
slightly with auxin application at 35°C but increased with 10 ppm IAA at 25°C (Table VIII).

**Salmalia malabarica**

**Number of cuttings rooted**: Table IX shows that rooting did not occur at all at 15°C even with auxin application like *B. tubiflorus* and *P. sissoo*. At 25°C only 2 control and IAA treated cuttings rooted as compared to 4 in IBA treated ones. The number of rooted cuttings increased in control and with 10 ppm IAA and IBA after 28 days.

At 35°C only 2 control cuttings rooted after 28 days. The number of rooted cuttings increased with 10 ppm IAA and IBA to 6 and 8, respectively after 28 days (Table IX).

**Number of roots**: Only a few roots were produced and the number did not differ much with auxin application at 25°C but was higher than the control with 10 ppm IAA and IBA at 35°C (Table IX).

**Length of root**: The trends of results of length of roots were more or less similar to the number of roots (Table IX).
ONTOTGENY OF ROOT INITIATION AND ANATOMICAL CHANGES WITH AGE

Experiment 17: This experiment was performed to study the ontogeny of root initiation and the anatomical changes, if any, that are brought about with age in *Bryophyllum tubiflorum*, *Diplodia sissoo* and *Salmalia malabarica*.

For details of experimentation, a reference may be made to Experiment 3 while for the procedure adopted for fixing the material and cutting, staining and mounting sections, reference may be made to 'Experimental Procedure' on page 54. Microphotographs of the transverse sections showing important features were taken and are presented in Figs. 86-95 for *B. tubiflorum*, in Figs. 96-105 for *D. sissoo* and in Figs. 106-114 for *S. malabarica*.

*Bryophyllum tubiflorum*

Anatomy of stem: Fig. 86 shows that the structure of the stem is typically dicotyledonous with parenchymatous cortex surrounded by a single layered epidermis and a ring of open, collateral and endarch vascular bundles surrounding the pith (Fig. 87). Some of the cortical and pith cells are tanniferous.

Ontogeny of root: The secondary roots are initiated from the cambium and may occur from the fascicular or intra-fascicular region. The first indication of root initiation is an increase in the size of nucleus in a few cambial cells (Fig. 88). This is clearly observable in Fig. 89 which is a photomicrograph of the particular part of the section on a
magnified scale. The enlarged nucleus takes a central position and undergoes divisions in both tangential and longitudinal planes producing a number of cells with a prominent nucleus in each (Fig.89). The divisional activity continues and as a consequence of which the mass of cells projects outwards (Fig.90) and constitutes the root primordium which, though not bound by a distinct layer of cells, can be made out clearly by the increased size of the cells with distinctly stained apical portion. Its presence is indicated by a dot-like bulge in the transverse section when seen with the naked eye (Fig.90). The cells of the primordium, then, elongate crushing the outlying tissue and the cells of the outer layer organizing themselves into an epidermis (Fig.90). The root primordium grows further by the division of some apical cells and protrudes out eventually bursting the epidermal layer. Vascularization, then, takes place starting from base and extending upwards (Fig.91).

**Anatomical differences with age:** Figs. 92-95 represent the anatomical structure as seen in transverse sections cut from 3, 6, 9 and 12 month old stems, respectively. It is observed that the cambium is active in all cases and cuts off secondary xylem tissue which increases with age forming a circular ring. There are hardly any structural differences in the anatomy of stem with age.

**Dalbergia sissoo**

**Anatomy of stem:** Fig.96 which is a photomicrograph of the
section of *D. sissoo* cut prior to planting exhibits a
typical dicotyledonous structure with an epidermis covered
over by a thick layer of cuticles and cortex consisting
of parenchymatous cells. Pericyclic cells are not clearly
distinguishable; vascular bundles are open, collateral and
endarch with uniseriate or biseriate rays and there is a
distinct pith in the centre.

**Ontogeny of root:** The initiation and development of root
primordia are shown in Figs.97-101. The intrafascicular
tissue becomes meristematic and forms a complete ring of
cambium (Fig.97). The first evidence of root initiation is
an increase in the size of nucleus in each of the few cambial
cells (Fig.98). The enlarged nucleus then takes a central
position (Fig.99) and the cells in that region show active
division in various planes resulting in the formation of a
group of cells which organise themselves into a root primordium
and is deeply stained (Fig.100). The ontogenic changes
occurring during the initiation of root in *D. sissoo*, thus,
closely resemble those in *E. tubiflorum*, described earlier.

The root primordium then increased in size by the
division and enlargement of cells and protrudes out of the
cortex. The meristematic activity is, then, confined to the
apical region. The vascular differentiation starts soon
after (Fig. 101) connecting ultimately with the vascular
cylinder of the main stem.

**Anatomical differences with age:** The stem structure undergoes
some changes with age. Thus, patches of fibres develop in
the cortex and there is an increase in the secondary xylem more or less completely obliterating the pith (Figs.102-105).

*Salmalia malabarica*

**Anatomy of stem:** Fig.106 shows typically a dicotyledonous stem structure. The stem is surrounded by a thin-walled non-cuticular epidermis followed by an undeveloped sclerenchymatous hypodermis. The cortex and pith are wide and are constituted of thin-walled parenchyma with a few cells containing tannin here and there. The xylem is dissected by wide vascular rays which dilate as they come out of xylem. There are patches of fibre-bundles in phloem.

**Ontogeny of root:** The root initiation takes place from the cambial region and the roots are formed both from the interfascicular cambium. The first evidence of root initiation is an increase in the size of the nucleus in a few cambial cells (Fig.107) as in *R. tubiflorum* and *R. sissoo*. Fig. 108 shows the position of a root primordium under low power. The enlarged nucleus takes a central position and undergoes divisions in all planes producing a number of cells each with a prominent nucleus (Fig.107). The cell division takes place in all directions resulting in the formation of a mass of cells projecting outwards (Fig.109). This primordium is not bound by a distinct layer at this stage but can be made out due to the contrast in staining and size of cells. This is followed by the organization of cells. The root primordium then emerges out ultimately bursting the epidermal layer.
Vascularization, then, starts from base extending upwards (Fig. 110).

**Anatomical differences with age:** The structure of the stem from 3-12 month old plants is shown by photomicrographs of their transverse sections (Figs. 111-114).

The stem did not become woody with age, as in *D. spinosa*, but the number of tannin cells increased so much so that in 9 month-old plants (Fig. 113) the outer layers of cortex and in 12 month-old ones (Fig. 114) almost the entire cortex became tanniferous. The fibrous tissue in phloem also increased with age.