VEGETATIVE PROPAGATION OF TREE SPECIES OF SOCIAL FORESTRY VALUE IN GARHWAL HIMALAYA

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BHATT, B. P. & TODARIA, N. P. 1990. Vegetative propagation of tree species of social forestry value in Garhwal Himalaya. Stem cuttings of *Debregeasia salicifolia* (D. Don) Rendl., *Sapindus mukorossi* Gaertn. Fruct., *Lagerstroemia parviflora* Roxb., *Prunus cerasoides* D. Don and *Quercus leucotrichophora* A. Camus were treated for 24 *h* with different concentrations of indole 3-acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA) and dichlorophenoxy acetic acid (2,4-D) and planted in earthen pots containing garden soil and sand (1:1) as the rooting medium. Watering was done regularly and the experiment was conducted in a green house under natural conditions.

Season played a crucial role besides treatment with auxins for root initiation. Only spring planting was able to trigger rooting in branch cuttings up to some extent. No general pattern was present in the rooting responses. However, moderate overall rooting was observed in *S. mukorossi* (41%) and *D. salicifolia* (29%), and poor rooting in *L. parviflora* (13%) and *P. cerasoides* (6%) in some treatments. *Q. leucotrichophora* had only callus formation (7%). While IAA, IBA and NAA were effective in *D. salicifolia* and *S. mukorossi*, only IBA was effective for root initiation in *L. parviflora* (100 and 200 ppm) and *P. cerasoides* (500 ppm). The sprout development in *D. salicifolia* was very fast and within 90 days the shoot length reached 96 *cm*.

Key words: Social forestry species - vegetative propagation - auxins - *Debregeasia salicifolia* - *Lagerstroemia parviflora* - *Prunus cerasoides* - *Sapindus mukorossi* - *Quercus leucotrichophora*

Introduction

Many productive and important tree species can not be used commercially in forestry because they are difficult to propagate. The main problems in producing planting stock of important indigenous tree species in Garhwal Himalaya are: (i) absence of seed grading and seed certification, (ii) lack of seed storage techniques and facilities, (iii) over exploitation of some of the very important useful tree species, thus short supply of seeds as some of them are now found in small patches only, and (iv) no major scientific work on seed viability, dormancy and germination have been conducted on the majority of indigenous tree/shrub species.

Raising planting stock by vegetative propagation, especially by stem cuttings, may be a possible solution to these problems. Moreover, multiplication of genetically desired plants within a short period can be successfully obtained by vegetative means, as the technique is less expensive and easy to handle. Auxins have shown promising results at various concentrations for rooting cuttings of several plant species (Heide 1965, Nanda *et al.* 1968, Nanda & Anand 1970, Nanda 1975, Brown & Sommer 1985, Puri & Shamet 1988).

In spite of voluminous literature published on vegetative propagation, very few reports are available on vegetative propagation of social forestry/ agroforestry species (Khosla *et al.* 1982, Nagpal & Singh 1986, Puri & Nagpal 1988, Puri & Shamet 1988). The multiplication of social forestry species is urgently needed today in Garwhal Himalaya. In these hills, biomass is the main source of energy due to poor socio-economic conditions as well as very high prices of commercial fuels (Bhatt & Todaria 1990).

We report the results of rooting of stem cuttings of some social forestry species (which are important fuel fodder species in the region) with the possibility of raising planting stock for social forestry/community forestry programmes in the Garhwal Himalaya hills.

Materials and method

The experiment was conducted in the experimental garden of H.N.B. Garhwal University (elevation 550 *m*; 78°-78°48' E longitude and 30° - 31° N latitude). Ten branch cuttings of *D. salicifolia*, *L. parviflora*, *P. cerasoides*, *S. mukorossi* and *Q. leucotrichophora* were obtained from more juvenile and healthy growing trees in nature at the four different seasons of a year namely, spring (February), summer (May), rainy (August) and winter (November). The cuttings were made 20 to 25 *cm* long and each thick basal 5 *cm* portion was dipped in aqueous solution of IAA, IBA, NAA at 100, 200, 500 and 1000 ppm and that of 2,4-D at 100 and 200 ppm solutions for 24 *h*. 2,4-D was tested at higher concentrations (Hartmann & Kester 1986). Synergistic solutions of IBA + NAA, IBA + 2,4-D and NAA + 2,4-D were also tested at 200 ppm level separately. Treated cuttings were planted in earthen pots filled with garden soil and river sand in 1:1 ratio and watered regularly; water logging was carefully avoided. Observations on sprouting were made after 30, 60 and 90 days of planting, while rooting responses were observed only after 90 days. The experiment was conducted from February 1987 to August 1988 in a greenhouse under natural conditions.

Results

Debregeasia salicifolia

IAA (500 ppm; Figure 1), IBA (500 ppm; Figure 2) and NAA (500 ppm; Figure 3) showed maximum sprouting percentage (60%) in the stem cuttings of February as compared to other treatments but the control set also sprouted (50%). Luxurious shoot growth was found (96 *cm*) with NAA 500 ppm after three months of treatment, which was followed by IAA 200, 500 and 1000 ppm (89, 87 and 87 *cm*, respectively). IBA was less effective in shoot growth at low concentrations and 1000 ppm IBA was able to enhance 60 *cm* shoot growth (Table 1). Poor sprouting was recorded with lower concentrations of IBA while NAA was more effective at higher concentrations. 2,4-D was ineffective and results were comparable to control.

Rooting response of *D. salicifolia* was observed only in February treated stem cuttings. All the concentrations of auxins produced a rooting response except IBA and NAA (1000 ppm) and 2,4-D at 100 ppm. Good rooting percentage (50-60) and roots/rooted cuttings (56 roots/rooted cuttings) were seen with the treatment of IAA at 500 and 1000 ppm concentrations (Figures 4, 5 & 6). Poor rooting percentage and roots/rooted cuttings were seen with IBA treatment (Figures 7 & 8). Moderate rooting percentage (40%) and roots/rooted cuttings were observed with 100 & 200 ppm of NAA (Figures 9 & 10). However, higher concentrations of NAA were inhibitory in action. 2,4-D which is harmful at higher concentrations to plants (Hartmann & Kester 1986), produced 40% rooting at 200 ppm concentration. There was positive correlation between sprout length and roots/rooted cuttingss as well as root length (Table 2). Generally, cuttings which had higher sprout length also had more roots/rooted cuttings as well as root length.

Sapindus mukorossi

Sprouting was observed in cuttings treated in all seasons of the year in *S. mukorossi.* Profuse sprouting was recorded in May. Lower concentrations of IAA, IBA and NAA produced maximum sprouts. Ninety percent sprouting was recorded with 500 ppm IAA and 200 ppm of NAA, followed by 100 ppm IAA and 200 ppm IBA (80%). Higher sprout length was observed with the treatment of 500 ppm IBA and 200 and 500 ppm NAA. Control set also sprouted (70%) but failed to root.

Only the February treated stem cuttings rooted and the stem cuttings in rest of the seasons did not root. There was no consistent difference in the rooting percentage in IAA and IBA. One hundred, 500 and 1000 ppm of IAA (Figures 11 & 12), 500 ppm IBA (Figures 13-16) and 100 ppm NAA (Figure 17) produced maximum rooting percentage (60%). High concentration of NAA

Table 1. Rooting, sprouting and callusing response of some social forestry tree species to auxins (February 1988*)

Treatments	Cuttings planted	Sprouts			Roots			Callus
		No. of cuttings sprouted after 90 days	No. of sprouts per sprouted cuttings	Average sprout length (*cm*)	No. of cuttings rooted after 90 days	No. of roots per rooted cuttings	Average root length (*cm*)	No. of cuttings callused
Debregeasia salicifolia:								
IAA-100 ppm	10	4	1.0	75.0±10.3	4	42.5±6.3	46.0±8.0	-
IAA-200	10	4	1.25	89.3±17.7	4	50.5±5.3	57.0±10.1	-
IAA-500	10	6	1.0	87.6±17.3	5	56.4±3.8	50.3±7.8	-
IAA-1000	10	4	1.25	87.0±15.3	6	57.9±4.7	56.3±12.4	-
IBA-100	10	2	1.5	29.5±11.7	2	42.5±3.4	38.2±9.6	-
IBA-200	10	4	2.0	27.5±5.3	2	36.5±9.3	45.1±14.4	-
IBA-500	10	4	1.0	58.3±10.3	4	30.5±5.1	40.2±5.1	-
IBA-1000	10	6	1.0	60.2±12.8	-	-	-	-
NAA-100	10	5	1.20	52.5±7.9	4	49.25±5.6	54.0±7.1	-
NAA-200	10	2	1.0	57.5±10.1	4	52.67±4.9	60.3±8.4	-
NAA-500	10	6	1.0	96.0±12.6	2	54.9±4.3	64.6±10.3	-
NAA-1000	10	4	1.5	80.0±20.3	-	-	-	-
2,4-D 100	10	4	1.25	-	-	-	-	-
2,4-D 200	10	4	1.5	37.5±18.9	4	26.5±3.8	37.2±7.3	-
Control	10	5	1.25	20.5±3.4	-	-	-	-
Overall success (%)	140	42			29			
Sapindus mukorossi:								
IAA-100	10	8	1.0	11.1±1.6	6	3.5±0.61	4.6±0.94	-
IAA-200	10	6	1.0	15.7±3.1	5	3.2±0.54	6.5±1.7	-
IAA-500	10	9	1.6	12.0±1.4	6	4.5±0.65	4.9±0.53	-
IAA-1000	10	6	1.0	7.7±1.4	7	2.6±0.33	2.6±0.29	3
IBA-100	10	7	1.0	14.1±2.3	5	3.4±0.51	6.0±1.07	-
IBA-200	10	8	1.25	6.1±1.1	5	3.0±0.34	3.9±0.81	-
IBA-500	10	5	1.0	34.7±4.5	6	10.5±1.96	11.5±1.94	-
IBA-1000	10	6	1.3	18.5±2.6	4	3.5±0.6	5.9±1.2	-
NAA-100	10	6	1.0	7.1±1.8	6	4.5±1.4	5.9±0.86	-
NAA-200	10	9	1.0	30.5±2.1	2	5.6±1.84	4.0±1.3	-
NAA-500	10	5	1.0	19.3±2.1	3	3.0±0.69	4.5±1.3	-
NAA-1000	10	4	1.25	15.3±3.3	-	-	-	-
2,4-D 100	10	6	2.0	12.1±1.8	-	-	-	-
2,4-D 200	10	5	2.0	12.2±1.8	-	-	-	2
Control	10	7	2.0	11.8±2.1	3	2.7±0.75	2.6±0.75	3
Overall success (%)	140	64			41			
Lagerstroemia parvifolia:								
IAA-100	10	6	2.5	10.5±1.4	-	-	-	-
IAA-200	10	7	2.0	12.5±1.58	-	-	-	2
IAA-500	10	6	1.5	9.5±1.27	-	-	-	-
IAA-1000	10	2	1.5	8.2±1.94	-	-	-	2
IBA-100	10	6	2.2	7.5±1.4	4	17.5±2.3	12.5±2.5	-
IBA-200	10	6	2.0	12.2±2.31	5	10.4±2.8	7.2±1.6	-
NAA-200	10	4	3.0	3.5±0.65	-	-	-	-
NAA-500	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 1. Continued.

2,4-D 100	10	3	1.7	4.5±0.79	-	-	-	-
IBA+NAA-200	10	7	2.6	3.6±0.47	4	7.5±1.45	8.5±1.72	-
Control	10	6	1.5	4.9±0.55	-	-	-	-
Overall success (%)	100	49			13			
Prunus cerasoides:								
IAA-100	10	4	1.0	9.0±2.3	-	-	-	-
IAA-200	10	3	1.7	9.5±3.2	-	-	-	3
IAA-500	10	3	1.3	10.5±2.2	-	-	-	5
IAA-1000	10	5	1.4	10.4±2.02	-	-	-	3
IBA-100	10	4	2.0	16.0±2.3	-	-	-	3
IBA-200	10	2	3.0	15.5±2.97	-	-	-	-
IBA-500	10	5	3.0	8.0±1.6	4	6.5±0.95	12.3±3.3	-
IBA-1000	10	2	1.5	6.5±1.6	-	-	-	5
NAA-100	10	2	1.0	3.5±0.85	-	-	-	-
2,4-D 100	10	2	1.5	8.2±2.6	-	-	-	-
Control	10	9	1.6	4.9±0.62	2	3.5±0.94	4.1±1.73	-
Overall success (%)	100	32			6			
Quercus leucotrichopra:								
IAA-100	10	6	3.8	8.2±1.0	-	-	-	-
IAA-200	10	7	3.4	6.5±0.57	-	-	-	2
IAA-500	10	4	2.0	5.3±0.7	-	-	-	2
IAA-1000	10	3	2.0	6.0±1.45	-	-	-	2
IBA-100	10	2	1.5	5.8±1.7	-	-	-	-
IBA-200	10	5	1.4	4.0±0.96	-	-	-	-
IBA-500	10	5	2.8	12.5±2.01	-	-	-	-
IBA-1000	10	2	3.0	10.0±2.5	-	-	-	-
NAA-100	10	6	3.0	8.5±1.84	-	-	-	2
NAA-200	10	6	2.8	9.0±0.96	-	-	-	2
NAA-500	10	4	2.5	12.5±1.78	-	-	-	2
NAA-1000	10	3	1.7	16.5±2.98	-	-	-	-
Control	10	5	1.8	4.0±0.67	-	-	-	-
Overall success (%)	120	44						

(± Standard Error; * Stem cuttings treated and planted in February showed sprouting as well as rooting in all the tested species, root initiation was also noted in this season. Therefore, results of other seasons have not been shown in the table. Only those treatments which triggered either shoot/root or both are mentioned here)

and both concentrations of 2,4-D completely failed to induce rooting in this species. Higher concentrations of IAA and NAA produced callus. The maximal number of roots/rooted cuttings was recorded in 500 ppm NAA, but maximum root length was obtained with 500 ppm IBA. Although control cuttings also rooted, the number of cuttings rooted, roots/rooted cuttings and average root length were insignificant (Table 2).

Lagerstroemia parviflora

Sprouting was recorded maximum in cuttings taken in February (70%) and treated with lower concentrations of IAA and IBA. Six sprouts/sprouted cutting were recorded with 100, 200 and 500 ppm IAA and 100 and 200 ppm IBA. Higher concentrations of auxins failed to enhance sprouting in this species. Sprouting response was also recorded in cuttings taken in May (40%) and treated with lower concentrations of IBA and NAA (100, 200 & 500 ppm). Cuttings treated in rainy (August) and winter (November) seasons failed to sprout.

Seasonal rooting response was seen in this species. In February lower concentrations of IBA (100 & 200 ppm) promoted rootings (Figures 18 & 19). Mixture of IBA and NAA at 200 ppm also induced root formation. However, IAA, NAA and 2,4-D failed to induced rooting at any tested concentrations in this species. One hundred ppm IBA was most suited for the induction of rooting, as this concentration produced 40% rooting as well as 17 roots/rooted cutting and 12.6 *cm* average root length after three month. In summer (May-August), stem cuttings showed 50% rooting ability with 200 and 500 ppm IBA and 35% with the treatment of NAA at 100, 200 and 500 ppm concentrations. Twenty percent rooting potential was seen with the treatment of IAA at 100 ppm. 2,4-D failed to induce rooting in this species also (these results are not shown in Table 1).

Table 2. Test of significance within the treatments

Treatments	Number of sprouted cuttings	Average sprout length	Number of rooted cuttings	Roots/ rooted cutting	Average root length
IAA vs IBA	NS	**A; ***C (++C)	***A	(++B)	NS
IAA vs NAA	**C,D,(+E)	*C; **D; ***E	NS	NS	NS
IAA vs 2,4-D	NS	NS	NS	NS	NS
IBA vs NAA	**D;	*A; **D; ***E; (++A)	***A	(++A)	(+A)
IBA vs 2,4-D	NS	NS	NS	NS	NS

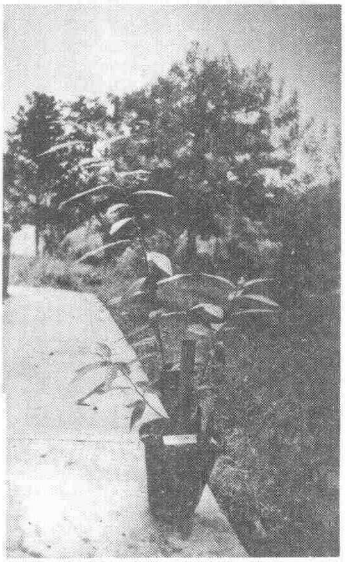
(Abbreviation used for 't' test: * significant at 0.01; ** significant at 0.05; *** significant at 0.1; NS Not significant; A = *D. salicifolia*; B = *S. mukorossi*; C = *L. parviflora*; D = *P. cerasoides*; E = *Q. leucotrichophora*; Figures in parenthesis represent positive correlation between two treatments; + = significant at 1% level, ++ = at 5% level)

Prunus cerasoides

Stem cuttings of this species sprouted only in the February treated cuttings. However, the control set produced higher sprouts (90%) than auxin treated stem cuttings. IAA (100 and 1000 ppm) and IBA (100 and 500 ppm) produced better sprouting response than other concentrations of different auxins. Poor rooting ability was seen only with 500 ppm IBA as well as in control. However, callus formation was recorded in 200, 500 and 1000 ppm IAA, and 100 and 1000 ppm IBA.

Quercus leucotrichophora

This is a hardwood species and showed better sprouting in February treated cuttings but its stem cuttings also sprouted in rainy and winter seasons. Table 1 shows that stem cuttings treated with 100 and 200 ppm IAA, 200 and 500 ppm IBA, and 100 and 200 ppm NAA sprouted much better (50 - 60%) than the other concentrations. Stem cuttings in control also showed 50% sprouting response. Yet all the cuttings failed to root in any season and concentrations of different auxins. However, callus formation was observed with 200 and 500 ppm IAA, and 100, 200 and 500 ppm NAA treated cuttings respectively.

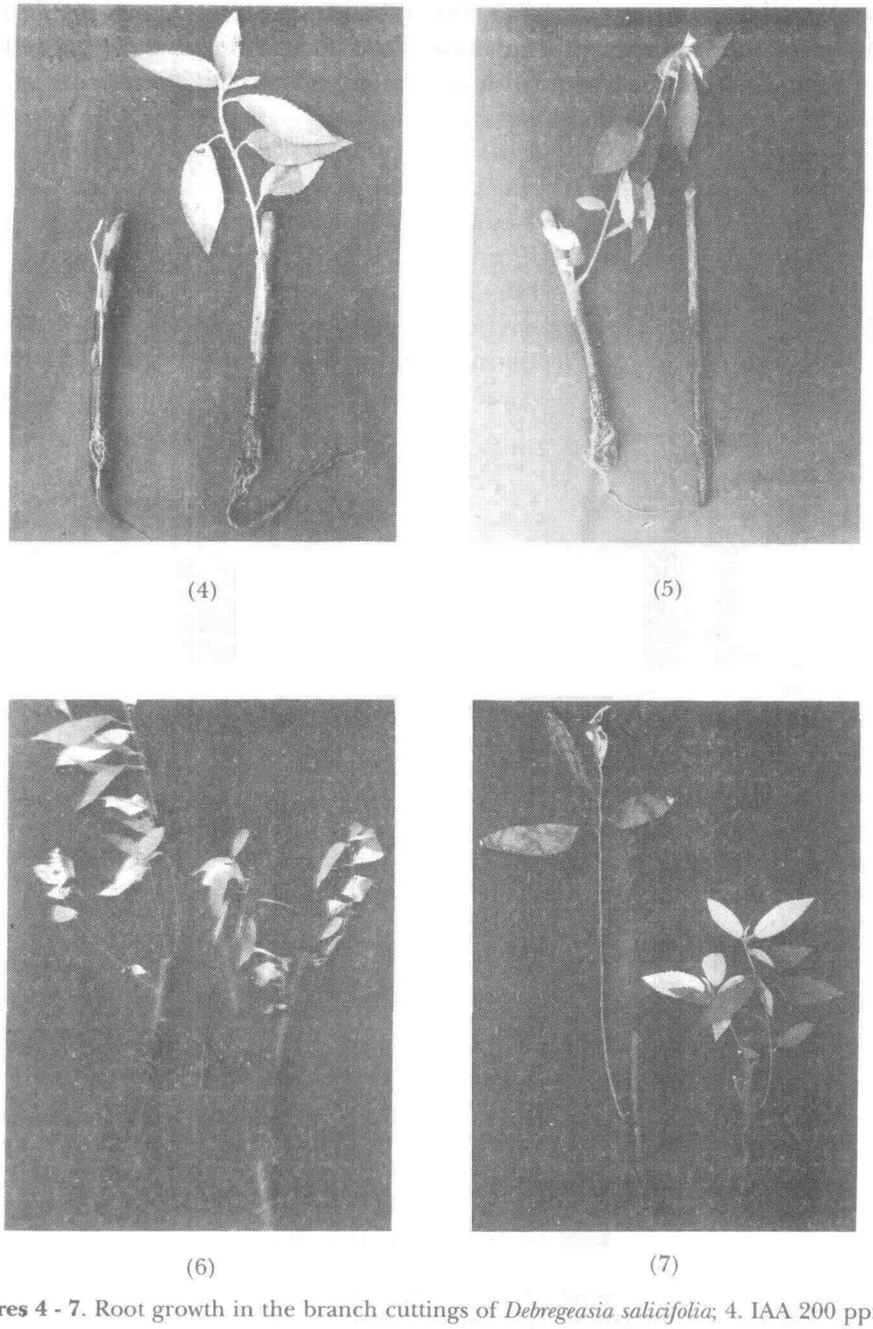


(1)

(2)

(3)

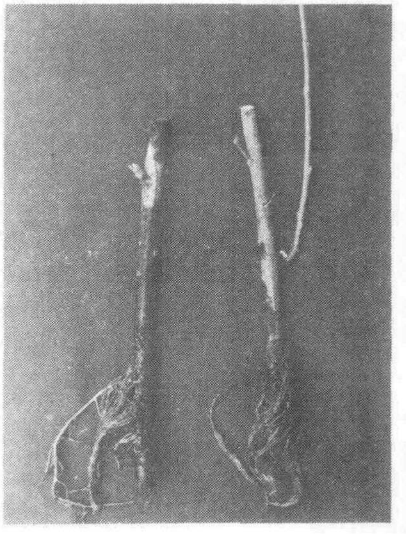
Figures 1, 2 & 3. Vegetative growth in the branch cuttings of *Debregeasia salicifolia*; 1. IAA 500 ppm, 2. IBA 500 ppm, 3. NAA 500 ppm



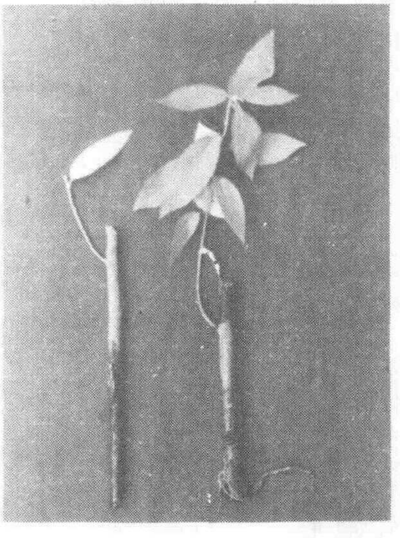
(4) (5) (6) (7)

Figures 4 - 7. Root growth in the branch cuttings of *Debregeasia salicifolia*; 4. IAA 200 ppm, 5. IAA 500 ppm, 6. IAA 1000 ppm, 7. IBA 200 ppm

(8)



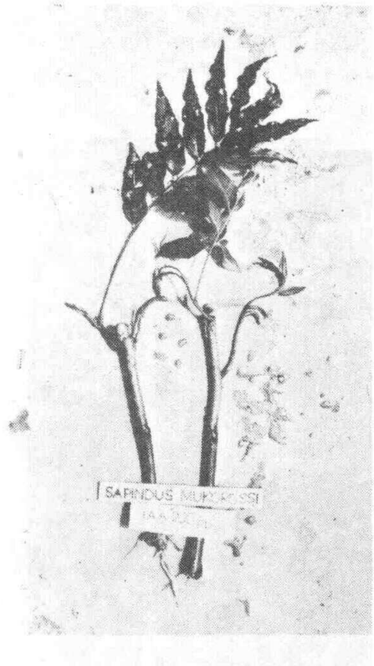
(9)



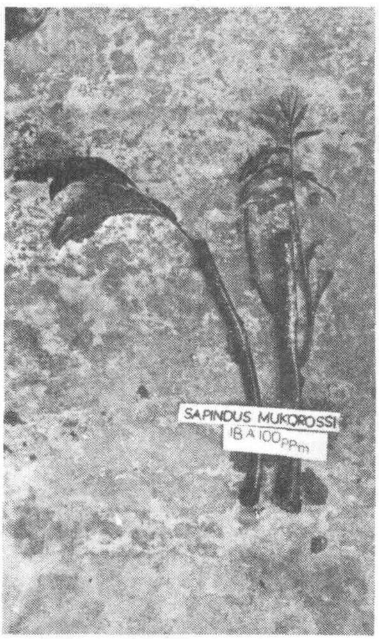
(10)

Figures 8 - 10. Root growth in the branch cuttings of *Debregeasia salicifolia*; 8. IBA 500 ppm, 9. NAA 200 ppm, 10. NAA 500 ppm

(11)



(12)

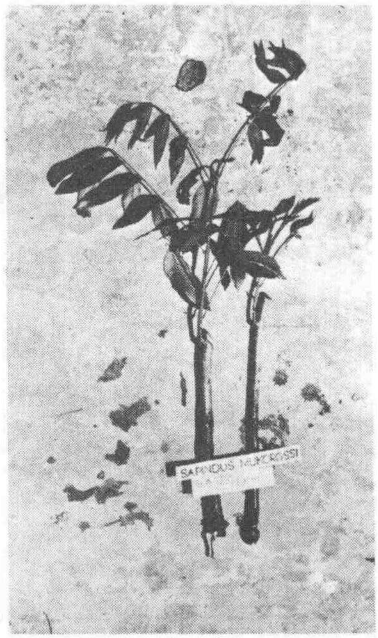


(13)

(14)

Figures 11 - 14. Rooting and vegetative growth in the branch cuttings of *Sapindus mukorossi*; 11. IAA 100 ppm, 12. IAA 200 ppm, 13. IBA 100 ppm, 14. IBA 200 ppm

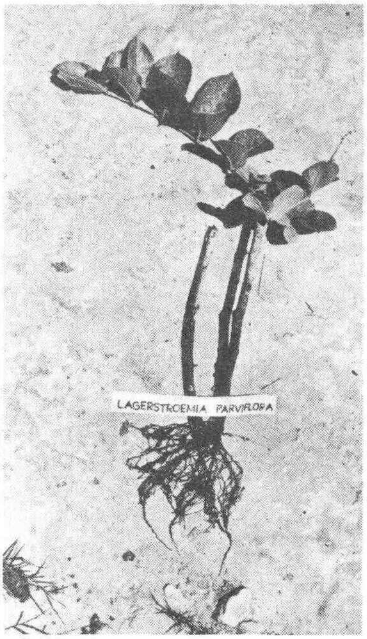
(15)



(16)

(17)

Figures 15 - 17. Rooting and vegetative growth in the branch cuttings of *Sapindus mukorossi*; 15. IBA 500 ppm, 16. IBA 1000 ppm, 17. NAA 200 ppm



(18) (19)

Figures 18 & 19. Rooting and vegetative growth in the branch cuttings of *Lagerstroemia parvifolia*; 18. IBA 100 ppm, 19. IBA 200 ppm

Discussion

The results of the present investigation and those achieved by earlier workers [Momose 1978, Halle & Hamif Kamil 1981, Srivastava & Mangill 1981, Khosla *et al.* 1982, Smits 1983, Puri & Nagpal 1988, Puri & Shamet 1988, Radvan *et al.* 1989, Bhatt & Todaria (in press)] indicate a wide variation in rooting ability of cuttings and inconsistent effect of different concentrations of various auxins.

All the species are woody and were difficult to root (Nanda 1975) except *D. salicifolia*, which is a large shrub or small tree. Our results clearly indicate that *D. salicifolia* and *S. mukorossi* are the most promising species for propagation by stem cuttings. *L. parviflora*, *P. cerasoides* and *Q. leucotrichophora* need further studies to develop the techniques. This may involve study of ecophysiological, biochemical as well as anatomical factors bearing on root initiation and development on stem cuttings.

A number of workers have reported that exogenous application of hormones induces rooting in a number of species (Longman 1980, Srivastava & Mangill 1981, Puri & Shamet 1988). The present study suggests that no general conclusion about the effect of a particular auxin on vegetative propagation of trees can be made. IAA at 1000 ppm was most favourable for inducing root formation in *D. salicifolia* (highest rooting percent, sprout and root length) as well as roots/rooted cuttings. IBA, though effective in root induction in *D. salicifolia*, was more favourable for root initiation in *S. mukorossi* at 500 ppm level and in *L. parviflora* at 100 and 200 ppm (highest rooting percent, sprout and root length as well as roots/rooted cuttings). NAA at lower concentrations up to 500 ppm level was able to induce root formation in *D. salicifolia* as well as in *S. mukorossi.* 2,4-D which is harmful at higher concentrations (Hartmann & Kester 1986), when applied at lower concentrations did not induce root formation in any species except *D. salicifolia. Q. leucotrichophora* and *P. cerasoides* did not respond to exogenous application of hormones. As all these experiments were conducted in natural conditions, some of the species which did not root may be induced to form roots if propagated under controlled environments - mist chamber *et cetera,* where a balance in temperature and water regime can be maintained (Reddy & Majumdar 1975, Srivastava & Manggil 1981, Hartmann & Kester 1986).

Seasonal stimulus plays an important role in the callus and root formation in trees. Seasonal effect is clearly visible in the present experiments. Only *L. parviflora* rooted in two seasons (February and May). All other tested species rooted only in cuttings taken in February. A number of workers have shown that rooting of cuttings is facilitated when carbohydrate reserve foods are in abundance (Kraus & Kraybill 1918, Knight 1926, Carlson 1929, Durham 1934). Much of the growth activities remain at minimum during winter, and as soon as the temperature starts rising above minimum from February onwards, the reserve food material (carbohydrate) is mobilised and helps in growth flushes. Thus cuttings made in the beginning of February are full of reserve food materials and the temperature also starts rising in this month, giving stimulus to sprouting and rooting. Thus vegetative propagation is easier compared to cuttings made in other seasons of the year.

Callus tissue plays an important role in rooting of cuttings from difficult to root species. In the species of *Abies, Picea* and *Pinus,* almost all of the adventitious roots arose from irregular parenchyma associated with callus or from callus alone (Satoo 1956). In this experiment, callus formation was observed in *S. mukorossi, P. cerasoides, Q. leucotrichophora* and *L. parviflora.* Among these species *S. mukorossi* rooted very well while in other species callus could not differentiate into adventitious roots. This can be attributed either to: (i) lack of sufficient food reserve, (ii) flagging, (iii) unfavourable temperature-moisture regime (relative humidity), (iv) some internal factors, and (v) the age of the cuttings (aged mature plant) (Girouard 1967, Bohga & Durzan 1982). The cuttings in this experiment were made from mature plants ≥ 10-y-old.

During vegetative propagation, early growth of sprouting depends on food reserve available in the cuttings (Wright 1975). This is followed by root formation, which enables the plant to absorb mineral nutrients from the growth medium. However, where root formation lags very much behind shoot formation, survival rate becomes very low and the plant is likely to die (Duguma 1988). A high incidence of flagging was observed in some species of dipterocarps (Srivastava *et al.* 1986) as majority of shoots wilted as the roots were not formed simultaneously. In our study good sprouting (shoot formation) was recorded in *P. cerasoides*, *Q. leucotrichophora* and *L. parviflora* but as root formation did not take place (or callus did not differentiate simultaneously), all the cuttings wilted sooner or later. According to Adriance and Brison (1955) low CHO/N ratio encourages better shoot growth but poor root formation. Thai (1977) also reported flagging in *Palaquium maingayi* cuttings. He suggested that early shoot formation might have an unfavourable effect on root initiation because this creates a competitive situation between root and shoot for nutrient reserves within the cuttings. Thus early shoot formation may exhaust nutrient reserve. This needs further investigations.

Nautiyal and Purohit (1980) reported that high land species of *Berberis* has better rooting potential than lowland *Berberis* species and the highland *Berberis* species rooted in winter months only probably due to the mobilisation of reserve food materials under low temperature (Wallace & Harrison 1977). However, the highland *Q. leucotrichophora* and *P. cerasoides* did not root even in winter months in our experiments.

Mist chamber facilities are being created in the Department of Forestry which will help to study and standarize the technique for those species which could not root under natural conditions.

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