STUDY ON THE PROPAGATION TECHNIQUES OF SOME IMPORTANT SHRUBS

THESIS

By

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Debregeasia hypoleuca, Wedd

Coriaria nepalensis, Wall

AFFECTIONATELY

DEDICATED

TO MY PARENTS

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CERTIFICATE - I

This is to certify that the thesis entitled "Study on the propagation techniques of some important shrubs", submitted for the degree of MASTER OF SCIENCE in FORESTRY (SILVICULTURE AND AGROFORESTRY) to Dr. Y.S. Parmar University of Horticulture and Forestry Solan, is a record of bonafide research work carried out by Mr. Sandeep Sharma S/o Shri Harish Chander Sharma, under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of research work have been fully acknowledged.

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CERTIFICATE - II

This is to certify that the thesis entitled "Study on the propagation techniques of some important shrubs", submitted by Mr. Sandeep Sharma son of Shri Harish Chander Sharma, to Dr Y.S. Parmar University of Horticulture and Forestry in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in FORESTRY (SILVICULTURE AND AGROFORESTRY) has been approved by the student's advisory committee after an oral examination on the same in collaboration with the nominee of the Dean.

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(SANDEEP SHARMA)

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CHAPTER I

INTRODUCTION

Shrubs yielding valuable produce of every day use i.e. fuel and cattle fodder, fibre etc outmanoeuvre the tree vegetation by their omnipresence as capable of sustaining themselves over edaphic and climatic conditions too severe for any tree growth. The immense utilisation potential of shrubs coupled with the capability and capacity to grow over poor soils,having a low moisture status qualify the shrub species as suitable for introduction in poor sites under the waste land afforestation schemes. Possibly the introduction of shrubs and bushes in poor site may provide a means of biological amelioration and rejuvenation of site as a prelude to introduction of tree species, specially over poor degradaded hill slopes. Shrubs can also perform as ideal fence surrounding forest plantations but may be used for expeditiously achieving the objective of augumenting supplies of scares fuel and fodder needed by our teeming millions over the shortest period.

The demand for fuel and fodder has tremendously increased due to ever increasing human and cattle population in India, which are the two basic needs of rural community. During the past three decades more than 40 million ha of new areas have been brought under plough causing disastrous effects on environmental imbalance, floods, droughts and wind storms. In India

80 per cent of rural energy is met from traditional sources. Fire wood constitute major source of rural energy. The major part of our annual forest biomass production is utilized as fuel and fodder. Thus rendering sizeable areas devoid of vegetation. The results are heavy losses of soil and water from exposed land particularly from hills.

The degradation of the entire Himalayan ecosystem is the subject of global concern. Huge tracts of Himalayas have been turned into wastelands and the process continues at an alarming rate. Destruction of forest ecosystem, is resulting in severe erosion, floods, landslides, receding of glaciers, drying up of water sources and ultimately upsetting not only the economy of the local people but also of people in the flood plains. The misery caused to the entire nation, due to ecodegradation of Himalayas is enormous and warrants urgent remedial measures (Maithani et al, 1986).

According to Col. Broync of the I.C.S., an authority on rural development, poverty in India is mainly due to soil erosion, a consequence of land degradation which may be effectively checked and reduced by, planting with shrub species. While 2/3 of our total available area is suffering from serious degradation of one kind or another balance 1/3rd of the land is lying unproductive. This situation does not sustain any economic production. The indiscriminate land exploitation for cultivation has led to intense soil erosion and depletion of greenery. The old saying that 'Forest is the forester mother of agriculture', remains a myth. For ensuring productive agriculture, it is necessary that land under forests/green cover is atleast double the area under agriculture (Ramakrishna Rao, 1989). Extensive deforestation has resulted in raised river beds and the silting of dams. This has led to depleted water carrying capacity and reduced irrigation potential. In India, projections by the National Commission on floods that an irrigation potential of almost 60,000 ha may be lost every year due to siltation amply illustrated the seriousness of the situation. The impact of deforestation not only disturbs developing countries but also developed countries because of ecosystem disturbances. If today's slow rate of afforestation and drastic deforestation continues, wood famine is not far off. This may ultimately lead to food famine in developing countries (Srinivasan and Caulfield, 1989).

With the denudation of hills, water run-off is increased both in amount and speed and infiltration is reduced. The top soil is washed away and transported to lower elevations through sheet erosion, gully erosion and landslides. River beds are deeply scoured by the increased water runs, thus endangering the steep slopes above and causing further landslides. The additional rubble, sand and silt transported by the torrents and rivers is deposited in the plains, raising the river beds there and causing floods and shifts in the courses of rivers as also the siltation of Hydro electric projects and irrigation canals. The increased run-off in the hills, results in less infiltration which reduces ground water level, resulting in the drying up of springs and wells. The impact is not only felt in the hills, but also in the plains, in the form of foods during the rains and drought during dry season.

Of all the measures, restoration of the vegetal cover to the degraded hills is the basic approach in the eco restoration strategy. The process of deforestation is linked to a vicious circle of man and its socioeconomic life. The ecodevelopment which is attributed to development of a particular area through integrated utilization of its physical, biological and cultural resources, is the only answer to prevent deforestation of the Himalayas. It emphasises the need to harmonize changes in cultural, economical and ecological factors, for meeting the fundamental requirements of the people on sustained basis. One of the basic strategies of eco development is to increase national and local self reliance and to integrate development within the socio economic fibre of the people, so that the objectives of meeting the food, clothing and shelter are realised in an environment which is mutual, stable and dynamic. The basic strategy in the eco development is to bring greenary to the weeping slopes of Himalayas so that the watersheds are revived and brought back to life. Maithani et al (1986) reports that nature itself initiates the process of redeeming the hills.

There is very little tree growth in all these areas, and these barren, rocky and broken slopes are clonised mostly by shrubs, and lateron by a few tree species. Thus natural process of reclamation of these hills is required to be augumented and the Himalaya's journey towards reclamation can take bivoiac in shrubs. These shrubs help the grotesque looking slopes to retrieve vegetation extinction. The prelude to afforestation through trees to create green cover is ensealed in regreening these hills initially by shrubs.

It has been observed by many researchers that mostly sclerophyllous shrubs and trees are the primary species, which colonise or hold ground on degraded lands. The capability of shrubs to adhere and colonise degraded lands is indication of nature's resistance to prevent degradation and also indicate the early steps in the revegetation of these hills. The sclerophyllous nature of shrubs helps them to withstand drought, frost, fire, wind and exist in extreme conditions of soil and water loss, as the nutrient requirement of these species is low, and elevated root/shoot ratio makes these species suitable for restoration of vegetal cover on the denuded lands. Thus the primary objectives of forest management and, therefore eco development concept, should be to protect these shrub growing areas from further destruction and also to take up plantation of these shrubs in large areas for creation of a shrub stratum which by the process of site improvement will make way for higher form of vegetation. Tree growth is difficult on the rocky, barren areas, severely eroded areas and cliffs at the initial stage. The growth of shrub-stratum, will create favourable conditions for tree growth by way of retaining moisture, increasing soil nutrient status, developing soil flora and fauna, sheltering the tree seedlings from frost, wind and other biotic interferences.

The shrubs are generally hardier more tolerent to frost and drought and resistant to pests and diseases. These characteristics make the shrubs more adaptable to their habitat. There are numerous shrubs of different species found growing throughout the sub Himalayan region. These shrubs are of high economic importance to the people. They not only promise to solve the problems of fuelwood and fodder for the local people, but can also strengthen their economy by way of their value in medicine, fruits and fibre. These shrubs may therefore desirable form part of the programme of eco development and management of watersheds. However, the basic priority in planting shrubs should remain, as a step towards restoration of vegetation and to subsequently create conditions for growth of trees. Useful shrubs simultaneously have a valuable role to play in hill agriculture as strengthening of field bunds, reducing run off rates, and maintaining soil fertility, conserving soil and augumenting the economy.

All the characteristics of useful shrubs make them exceptionally suitable for growing on commercial scale or as social forestry species. To accomplish the task, huge quantities of plant material will be needed which is possible with the development of suitable, low cost propagation techniques for desirable shrubs species. In the absence of standard propagation methods, it is neigh impossible to move ahead in the utilization of useful shrubs. In relation to social forestry, it would be very difficult to persuade the people, unless proper growing technique, supply of seed and planting material are made available and economic viability demonstrated and above all proper measures are taken for economical utilization of the product considering the above said, the present investigations were envisaged with a broad objective of evolving a simple, rapid and inexpensive propagation techniques of a few indegenous shrub species (Woodfordia floribunda, Debregeasia hypoleuca, Berberis lycium, Coriaria nepalensis), to enable gainfully utilize this natural wealth. The main emphasis laid on the following:

i) Determine germination per cent and germination energy of local indegenous shrub species seeds

ii) ✓ Determine the propagation technique through seeds

iii) ✓ Determine optimum season for rooting stem cuttings under nursery conditions

iv) ✓ Study effects of IAA, IBA and NAA in rooting of stem cuttings under nursery conditions.

CHAPTER II

REVIEW OF LITERATURE

The literature reveals some studies on propagation techniques of shrubs but the information available is very scanty. Due to the limitations stated, the review on findings have been enlarged to include also literature on propagation techniques of forest trees, as having found special favour with researchers and appears equally meaningful with relation to propagation of shrub species. The cited literature for convenience and also maintaining hormony with aspects of shrub propagation taken up in the current study have been divided under two heads.

1) Propagation by stem cuttings
2) Propagation by seeds

1. Propagation by stem cuttings

Stem cutting are an important mean of vegetative propagation especially providing a fast and simple tool for replicating clonal material. Vegetative propagation methods are gradually gaining ground with the need for expediency in creating man made forests. Besides vegetative propagation is generally relatively cheaper and an insurance against uncertainities regards good seed years, a major hurdle to an assured supply of planting stock to meet the afforestation targets.

The multiplication of plants with desireable traits by cuttings is an old practice followed since time immemorable. The first scientific paper on rooting of cuttings was, however, published by Duhamel du Monceau over two centuries ago in 1758. A considerable amount of literature dealing with different aspects of rooting has since accumulated revealing that rooting potential of plant species varies considerably (Corbett, 1897; Vanderlick, 1925; Jiminez, 1937; Stoutmeyer, 1937; Thiamann and Delisle, 1939; Deuber, 1940; Mes, 1951; Sachs et al., 1964; Fadl and Hartman, 1968; Nanda et al., 1968; 1970; Bhatnagar and Joshi, 1973; Libby, 1974; Carville, 1975; Saul and Zsaffa, 1978; Ellyard, 1981; Wise et al., 1985; Hartmann and Kester, 1986; Nanda and Kochar, 1986; Kanwar, 1988).

Cuttings of plants exhibit wide variability in their ease to rooting some showing a fast response while other posing difficulties. There are numerous reports on the rootability of shoot cuttings of many forest trees (Yin and Liu, 1948; Fielding, 1954; Ohmasa, 1956; Neiustaed et al., 1958; Schieber, 1963; Mcknight, 1970; Hill and Libby, 1970; Kleinschmit, 1972; Sargento and Barker, 1978; Ujavari, 1981; Fraysee et al., 1984; Nanda and Kochar, 1986; Oodoual and Akunda, 1988; Puri and Shamet, 1988; Pal, 1989). Based on the rooting behaviour of branch cuttings, Nanda (1970) divided forest trees in to three categories easy to root, difficult to root and obstaniate to root type. Chandra and Khushudil (1977) reported that Spiraea sorbifolia Linn can be easily multiplied by hard wood stem cuttings, 52 per cent of cuttings rooted without any aid of root promoting hormone and irrigation. Chandra (1978) reported that in case of Magnolia grandiflora stem cuttings, 32 per cent cuttings were able to produce roots when cuttings were three season old and without aid of root promoting hormone. Gupta and Chandra (1979) reported that Abies pindrow, Cedrus deodara and Pinus gerardiana were difficult to root as compared to rooting of other stem cuttings. Puri and Shamet (1988) reported that Grewia optiva, Celtis australis, Robinia pseudacacia were hard to root whereas Populus deltoides and Leucaena leucocephala easily rooted without any auxin application.

Vegetative propagation by stem/branch cuttings is the standard practice for propagating poplars (Seth and De Sarkar, 1960; Seth, 1969; Mathur, 1972; Pande, 1973). Maini (1968) and Sekawin (1969) reported that most of the membeers of the genus Populus especially the bat-sam poplar and cotton woods are easily propagated by rooting of stem cuttings, while quaking aspen are difficult to propagate. Jobling (1970) concluded that Populus and Salix species and Platanus acerifolia easily propagated under open nurseries while some other popular hybrids can be propagated under indoor conditions. Hong (1972) observed the rooting potential of Alnus hirsuta and noticed that cuttings from coppice shoots rooted better than normal shoots. Kleinschmit (1972) reported the rooting of cuttings in 21 clones of Norway spruce and obtained best results with vegetative propagules drawn from juvenile plants under mist conditions. Lepisto (1972) reported 77 per cent rooting in Picea abies, 16 per cent in Pinus sylvestris and 43 per cent in Alnus incana under green house conditions. Guhathakurta (1973) reported that branch cuttings of most of the poplar species root easily without any pre-treatments of synthetic growth regulators but cuttings of Populus gamblei do not root easily.

Kormaink and Brown (1973) reported 80 per cent and 50 per cent rooting in stem cuttings of sweet gum (Liquidambar styraciflua) and yellow poplar (Liriodendron tulipifera) respectively under modified growth chamber. Sargento and Barker (1978) observed the propagation of Pinus caribaea and Pinus oocarpa by needle fascicles and noted 97 and 76 per cent rooting respectively. Mason (1984 a) reported good rooting percentage in lodge pole pine, Douglas fir, Norway spruce, Western hemlock and Thuja plicata while only 20 per cent rooting in Abies grandis. Mason (1984 b) reported 70-80 per cent rooting in stem cuttings of sitka spruce with the help of growth regulator treatments. Harsh and Muthana (1985) tried to raise the plants of Acacia albida by cuttings. They reported success with the aid of root hormone but did not study the performance after planting. Terasma (1985) observed 90 per cent rooting in stem cuttings of Norway spruce (*Picea abies*) with application of growth regulators. Parvez Ahmed (1987) successfully raised *Acacia albida* from the shoot cuttings without aid of root hormones. The sprouted plants not only developed a healthy root system but also showed vigour and continuous growth in plantation.

Promotion of root induction by Auxins

The existence of some specific root inducing substance was first postulated by the famous German botanist Sachs in 1882. Only on the basis of such an assumption, some of his observations on rooting of cuttings could be explained. However, it was not until over 40 years later when Lek (1925) working with cuttings of grapes and other woody plants was able to demonstrate the existence of such a substance.

Later work by subsequent researchers led to the discovery of root promoting substances and named as auxin (Went, 1929, 1935; Thimann and Went, 1934; Thimann and Koepfli, 1935). This discovery led to important practical applications of auxins. Definite improvement in rooting of cuttings with auxins has been reported by numerous workers (Thiamann and Went, 1934; Went, 1935; Cooper, 1936; Hitchcock and Zimmerman, 1936; Defrance, 1938; Swingle, 1940; Hartmann, 1946; Schravdolf and Reinert, 1959; Leopold, 1960; Farmer, 1966; Thiamann, 1967; Nanda et al., 1970; Hartmann and Kester, 1976; Hinesley and Blazich, 1980; Negi et al., 1982; Lahiri, 1983; Chandra and Yadava, 1986; Gurumurti et al., 1988). There are many plant species known which do not root even with the application of auxins (Pearse, 1939; Hatcher and Garner, 1947; Tyce, 1957; Nanda et al., 1968; Anand et al., 1970; Mamgain, 1986 and Pal, 1989).

Jauhari and Rehman (1959) reported an increase in rooting percentage in *Citrus limettoides* with NAA. Libby and Conkle (1966) reported IBA to be most effective in inducing rooting of *Pinus radiata* cuttings. Barry and Sachs (1968) noted that IBA application to stem cuttings significantly increased rooting per cent in quakingaspen as compared to other treatments. [Verma et al. (1971) reported best rooting in cuttings of *Carandus* spp. and *Morus alba* with the application of 4 per cent sugar solution and 5 per cent sugar plus IBA solutions.] Eggens et al. (1972) reported that hard wood cuttings of Bollinea poplar taken during April month rooted better with application of IBA treatments. Kleinschinst (1972) observed 45.4 per cent rooting in Douglas fir (*Pseudotsuga taxifolia*) cuttings when treated with indole acetic acid. Bhatnagar and Joshi (1973) reported that IBA considerably increased rooting response in *Eucalyptus tereticornis* Lingnotubers. Lahiri (1973) observed that the effect of IBA is beneficial in rooting vegetative cuttings in general as inferred from trials on different species. Purkayastha and

Kumar (1973) reported that IBA with mixture of other auxins induced higher percentage of rooting in cuttings of Albizzia lucida, Benth. Ragnose et al. (1973) obtained best rooting in cuttings of Populus deltoides with application of 50 mg/lt.IBA. Camarsen and Rook (1974) found IBA to have a positive effect on both callus formation and root initiation in stem cuttings of Pinus radiata. Bhatnagar (1977) observed that rooting in stem cuttings of Pinus roxburghii greatly increased by IAA treatment. Ghosh and Bhatnagar (1977) observed the growth regulators to considerably increase rooting in branch cuttings of Populus gamblei Dode a twenty four hours dip treatment in aq. solution of 200 ppm conc. of IAA provided the best results with 70 per cent rooting achieved. Rahaman (1977) observed increased rooting per cent in cuttings of Tectona grandis, Gmelina arborea, Legerstroemia speciosa and Albizzia procera with IAA and IBA treatments. Goi et al. (1978) reported that NAA/IBA (0-50 ppm) was ineffective with hard wood cuttings of Chaenomeles species in response to root formation. Gupta and Chandra (1978) observed best rooting in stem cuttings of Pinus roxburghii, Pinus wallichiana and Picea smithiana under mist chamber. Lahiri (1979) reported the effect of parahydroxy benzoic acid and Indole Butyric Acid as favourable to rooting Populus gamblei, Dode, and Cryptomeria japonica cuttings. Lohani et al. (1980) observed the rooting of stem cuttings of 69 species with the application of various growth regulators. Green Wood et al. (1980) reported that mist and chemical treatments enhanced rooting in loblolly pine (Pinus taeda) and short leaf pine (Pinus echinata) cuttings.

Lowery (1980) reported 80 per cent rooting success in upright branch cuttings of Pinus caribaea var. hondurensis treated with IBA. Adil Al-Kinary (1981) reported IBA treatment to provde significant result in number of roots, survival and other plant characteristics in Populus alba, P. tremula and Juniperus communis. Dirr (1981) gave a review of the principal growth regulators used for rooting cuttings. Various formulations, concentrations, combinations and application methods are discussed, but effectiveness of a rooting compound is essentially based on the presence of IBA, NAA or their derivates. Hinesley and Blazich (1981) reported that Auxin consistently increased rooting percentages, number and length of roots in case of Fraser fir stem cuttings. Pain and Roy (1981) reported best rooting in stem cuttings of Dalbergia sissoo during summer with the application of IBA and NAA following quick dip method and during winter with the application of IBA following quick dip method. Plotnikova (1981) reported that most cuttings from 117 endangered woody species, which were collected in summer and treated with IAA or IBA mostly provided best results when treated with IBA at 0.01 per cent concentration.

Sawhney and Kaur (1981) observed that IBA and NAA increased root development on hypocotyle cuttings of Phaseolus mungo, as both the auxins promoted root initiation considerably and also showed concentration effect. Hassig(1982) observed some endogenous root factors as being responsible for rooting in Pinus banksiana seedling cuttings. Janson and Wcislinska (1982) reported the best rooting of birch cuttings with application of IBA (50 mg/lt.). Marino (1982) observed enhanced rooting in stem cuttings of Pinus taeda, Pinus plaustris and Pinus elliottii with different auxin treatments under controlled conditions. Mathur and Guillot (1982) reported IAA hormonal stimulant as best in increasing rooting of stem cuttings of Alnus glutinoso. Morimzato and Yonemori (1982) observed good rooting percentage in woody cuttings of mulberry under mist chamber supplemented with auxin treatments. Negi (1982) reported IBA to be the most effective hormone in increasing the rooting of Dalbergia latifolia stem cuttings. Tanwar et al. (1982), observed maximum number of root formation in Opuntia elatior cuttings with lower concentrations of NAA. Briston (1983) found rooting in softwood cuttings of Leucaena leucocephala treated with various auxins to increase considerably. Kralik and Sebanek (1983) noted greater rooting response with IAA (200 ppm) and IBA (50 ppm) in Alnus glutinosa stem cuttings. Singh and

Bansal (1983) reported that rooting in female cuttings of *Populus deltoides* considerably increased with IBA and NAA treatments. Sunderan et al. (1983) observed 80 per cent rooting in *Bambusa arundinaceae* cuttings treated with 200 ppm NAA. Negi and Tewari (1984) found indole butyric acid to be most effective in rooting of stem cuttings of *Pongamia pinnata*, while NAA treatment exhibited moderate response with considerable variability in rooting potential and subsequent vegetative growth. Ye (1984) studied the effect of plant growth regulators on rooting behaviour of several species and found that (NAA 100 ppm) and IBA (200 ppm) to be most effective treatments in rooting cuttings of very many trees species.

Lo (1985) observed IBA application to be most effective in increasing rooting per cent of *Shorea macrophylla* cuttings as COMPARED TO NAA and NAA+IBA solutions. Tang and Srivastava (1985) obtained best rooting in stem cuttings of *Gmelina arborea* with IBA plus NAA treatments as compared to controls. Wise et al. (1985) studied the rooting performance of soft wood cuttings of *Abies braseri* and obtained best results with IBA (1500 ppm). Chandra and Yadava (1986) reported that soft wood stem cuttings of *Eucalyptus hybrid* rooted better with application of IBA. Puri and Shamet (1988) observed that IBA 100 ppm increased rooting in stem cuttings of *Grewia optiva* and *Robinia pseudacacia* as compared to control. Shamet and Kumar (1988) reported that exogenous application of auxins promote root formation in cutting taken from one year old branches of Punica granatum and Dalbergia sissoo under controlled conditions. They also found that auxin not only enhanced root formation but also increased the number of roots/cutting and average root length.

(Bahuguna (1988) reported application of 200 ppm of IBA for 24 hours in promoting rooting cuttings of Woodfordia fructicosa.)

Season variation and other factors in rooting

The season has paramount influence in rooting of stem cuttings. Some species root throughout the year while others are seasonal in their rooting response. The magnitude of rooting even in species that root throughout the year varies considerably with season (Hitchcock and Zimmerman, 1930; Dore, 1953; Sandaved, 1964; Morishta, 1964; Nanda et al., 1968; Roberts and Fuchigami, 1973; Anand and Heberlein, 1975; Pain and Roy, 1981; Chauhan and Sehgal, 1982; Nanda and Kochar, 1986; Hartmann and Kester, 1986; Rana et al., 1987). (The seasonal periodicity of rooting in stem cuttings associated with growth phase has been established for number of coniferous trees (Deuber and Farrar, 1940; Lamphear and Mehal, 1963; Roberts, 1969; Morgenstern, 1987)] Wareing and Smith (1963) reported that actively growing softwood cuttings of Populus rooted best in June-July but dormant hardwoods rooted better in autumn season. Deolle and Mitchell (1964) reported spring to be the best season for rooting of stem cuttings of many plant. Nichloson (1965) considered that February-May months to be ideal for rooting of stem cuttings of Bamboo wood and cotton wood. Chase and Strain (1966) found that vegetatively propagated material provides an excellent control parameter in investigations of the effect of various environmental factors on plant growth.

Variation in response due to season were also recorded by Nanda et al., (1968); Nanda (1972); Bhatnagar (1973); Ghosh and Bhatnagar (1977). Marygina (1968) reported that stem cuttings of *Picea abies* rooted best when taken from the mother plant in early spring before the bud break or in mid summer after the cessation of extension growth. Vitez and Penail (1968) reported highest rooting per cent of stem cuttings taken from mother plant during the active period of growth. An annual rhythm in rooting response of stem cuttings has been reported by many workers (Bhatnagar et al., 1963; Bhatnagar, 1973; Bhatnagar and Joshi, 1978; Nanda and Kochar, 1986). Roberts and Fuchigani (1983) reported seasonal variation in rooting of Douglas fir cuttings and they observed February-March as best months for rooting. Rindallo (1977) reported substantial seasonal variation in rooting of stem cuttings of *Alnus cordata*. John (1979) reported summer as the best season for rooting of

Larix nerolepis. Jobling (1981) reported the rooting of broadleaved trees from cuttings and found that cuttings taken during early season, planted in vermaculite and peat usually rooted best compared to other seasons. Chauhan and Sehgal (1982) reported that season has played vital role in rooting of stem cuttings of *Grewia optiva*, *Cordia dichotoma* and *Morus alba*. Cunningham and Farmer (1984) obtained best rooting in cuttings of balsam poplar planted during April. Fraysee et al. (1984) reported that spring was the best season for rooting of *Pinus taeda* supplemented with weak treatments of NAA or strong concentrations of IAA. Schlutea (1985) reported June-July months as best for rooting of willows. Rana et al. (1987) observed better rooting per cent in stem cuttings removal during April-May vis-a-vis the rest of the year.

The ability of cuttings to root decreases with the age of mother plant. Beakbane (1961) and Goodin (1965) considered that decrease in rooting response with age was due to some anatomical changes in stem structures. Gorter (1961) attributed it to a decrease in the reactivity of auxins with advanced age of the mother plant. Generally the cuttings taken from juvenile plant materials forms adventitious roots easily, whereas there is a gradual loss of rooting potential with advancing age (Komissarov, 1964; Hartmann and Kester, 1968; Kleinschmit and Schmidt, 1977). Root formation at the base of the cuttings is also influenced by several physiological factors like temperature, light, water, oxygen, humidity and mineral nutrients etc. Any change in the above factor modify the rooting response and vegetative part of the plant considerably (Eliasson, Stromquist and Brunes, 1977).

The seasonal changes in rooting response of stem cuttings have been ascribed to either changes in food forming substances (Klein, 1935) or to physiological status of the cuttings or to changes in the endogenous content of growth substances (Nanda and Jain, 1971; Nanda and Kochar, 1985; Hartmann and Kester, 1986; Pal, 1989). Among the factors affecting rooting of the cuttings, position of the shoot plays an important role. Basal cuttings were superior to apical in several plant species (Mukherjee et al., 1966; Yamdagni and Sen, 1973). The effectiveness of exogenously applied auxins varies with the season and may be ascribed to changes in nutritional and hormonal status during the annual cycle of plant growth (Nanda et al., 1970). Gupta and Chandra (1979) reported 63.5 per cent rooting in softwood cuttings of Chir pine as compared to 20 per cent rooting in mature cuttings. Lahiri (1983) reported best rooting in juvenile stem cuttings of some conifers as compared to mature trees. Jonson (1986) obtained 99 per cent rooting in succulent cuttings from 11 week old Picea abies. Kwon et al. (1987) reported that the juvenile (2 years old) cuttings of Picea abies, *Quercus acutissima*, *Pinus rigida* induced 92 per cent, 97 per cent and 84 per cent rooting respectively. Moon et al. (1987) reported that ore year old seedlings of *Quercus acutissima* showed 84.4 per cent as compared to 58.3 per cent rooting in three years old seedlings. Yang and Wang (1988) reported that soft wood cuttings of *Populus diversifolia* showed good rooting percentage as compared to hardwood cuttings.

2. Propagation by seeds

Seed is the common means of propagation for self and cross pollinated plants. Most seeds present no problem in germination and germinate when sown in appropriate season and stage of maturity. The success of a massive programme depends on the availability of quality seeds in desired quantities. Collection of seed in large quantities present several problems and also dependent on seed bearing behaviour of the species. Some species bear fruit/seed in good quantities fairly regularly every year, while others do so in intervals of one to several years. The maturation pattern of fruits also in some cases pose problems. There being 'simultaneous' type of fruit which mature at the same time, are easy to harvest and 'intermittent' type which mature over a long interval thereby making harvesting difficult and expensive (Maithani et al., 1989).

The seeds of many species fail to germinate inspite of the presence of favourable environmental conditions. Janick

(1974) termed this state as seed dormancy, seed dormancy has been attributed to one or more of the following reasons (Barton, 1965; Lang, 1965; Stokes, 1965; Wareing and Phillips, 1970).

1. Hard and impermeable seed coat
2. Immaturity of the embryo
3. After ripening in dry storage
4. Light sensitivity of seeds.

Various workers have reviewed the above factors from time to time (Flint and McAlister, 1937; Barton, 1965, 1967; Nikslava, 1969; Brant et al., 1971; Villiers, 1974). Donelly (1970) reported that besides environmental factors, the genetic component of the species also causes dormancy. Schophymeyer (1974) reported that most shrub species have embryo dormancy in which germination is enhanced following a period of chilling at low temperature i.e. 2-5°C. Seeds of Viburnum, Vitex, Cotonegaster and Crataegus possess a double dormancy i.e. embryo dormancy in addition to a mechanical dormancy imposed by an impermeable seed coat. From the forester's point of view dormancy has some disadvantages. Delayed and irregular germination in the nursery is a serious impediment to efficient nursery management (Bonner et al. 1974). Fully ripened seeds retain viability longer than seeds collected when immature (Stein et al. 1974, Harrington, 1970). Certain biochemical compounds, essential for preserving viability, may not be formed until the final stages of seed ripening. These include dormancy-inducing compounds in certain species and dormancy is sometimes associated with seed longevity.

Seeds of plant species when stored at low temperature and low moisture content, should prevent the development of fungi and insects as a result of modified conditions. It is necessary, however, to avoid deterioration of seeds showing a high incidence of fungal or insect attack, all operations of collection, transport, processing etc. must be carried out expeditiously to prevent any damage or deterioration before it goes into storage. Attack by fungi and insects is most rapid on the forest floor, therefore, ground collection should be done soon after fruit fall. Fungicidal treatment is generally not recommended since it can be harmful to seed (Magini, 1962); many fungicides are only effective when dissolved in water and are inappropriate for dry storage. Moisture content (MC) is probably the most important single factor in determining seed longivity (Holmes and Buszewicz, 1958). Reduction in moisture content causes a reduction in respiration and thus slows down ageing of seed and prolongs viability. Prevention of fungal activity is more easily achieved by controlling MC than by controlling temperature. If MC and RH are high enough, fungal activity is possible between -8°C and + 80°C (Roberts, 1972) and it is easier to keep MC below 12-14 per cent (or RH to the equilibrium of around 65 per cent) than to maintain sub zero temperature.

Seed treatment

A number of treatments involve soaking seeds in water or other liquids. These wet treatments may combine the effects of softening hard seed coats and leaching out chemical inhibitors. Some seeds which have little resistance to germinate may respond well to soaking for 24 hours in water at ambient temperature (Kemp, 1975). This may be the result of a more rapid imbition than can be achieved in a moistened nursery bed. It is recommended for some species after manual, mechanical or acid scarification (Seeber and Agpaoa 1976; Elamin, 1975).

Matias et al. (1973) found that 48 hours soaking of Pinus caribaea seed in water at room temperature gave more uniform germination than in the untreated seed. Vaenica (1973) reported that the seeds of Albizia falcata when soaked in water at 38°C for 20-30 minutes before sowing gave optimum germination. Hot water treatment has given good result with a number of leguminous seeds. The seeds are usually placed into boiling water removed from the heat source and left to cool gradually, the seeds remaining in the water for about 12 hours (Kemp, 1975). They imbibe and swell as the water cools. According to Hartmann and Kester (1976) the purpose of soaking seed in water is to modify hard seed coats, remove inhibitors, soften seed and reduce the time of germination. Sheikh (1980) studied the effect of boiling water on germination of seeds of Cassia *fistula* and observed 67.5 per cent germination after 24 days. Bowen and Eusebio (1981) found that in *Acacia manguim* seeds in Sabah there was a close correlation between the initial temperature of the water and the subsequent germination. Germination increased progressively from 5 per cent after immersion in water at 30°C to 91 per cent immersion at 100°C. Pathanath (1982) reported that soaking in water, for periods varying from 2 to 48 hours according to species, accelerates germination in *Acacia mearnsii*, *A. melanoxylon*, *A. nilotica* subsp. *Kraussiana*, *Adenanthera microsperma*, *Albizzia amara*, *A. procera*, *Grevillea robusta* and *Tremia nudiflora*. Turnbull (1983) reported that soaking of seeds in running water for one to two weeks has been used successfully to remove inhibitors in *Atriplex* spp.

Chemical stimulants

A wide range of chemicals have been tested experimentally for an attempt to overcome internal dormancy. They include gibberellic acid, citric acid, hydrogen peroxide and a number of other compounds. Bachelard (1967) found that the germination of dormant seeds of *Eucalyptus delegatensis*, *E. fastigata* and *E. regnans* could be improved by treatment with gibberellic acid (GA_3). Gibberellic acid (GA_3) is known to increase germination percentage in some dormant seeds (Hartmann and Kester, 1976). Dahab et al. (1979) reported that soaking of seeds of *Pistacia* khinjuk Stocks in GA_3 at 0, 100 and 1500 ppm for 24 hours increased the germination percentage from 18 to between 76 and 96 per cent. 24 hours immersion in either GA_3 or $GA_{4/7}$ of Nothofagus obliqua seed has been given rapid and complete germination in 14 days, although this normally dormant species otherwise requires 28-42 days stratification (Gordon 1979). Shafiq (1980) found that soaking Nothofagus obliqua and N. procera, Oerst seeds in 50, 100, 150 and 200 ppm GA_3 solution for 24 hours had a highly significant effect on rate and percentage of germination, it decreased the germination period to 8-14 days and 6-10 days instead of 28 days, respectively.

Carpenter and Smith (1981) reported that the seeds of Paulownia tomentosa treated with GA_3 germinated sooner and reached 98 per cent germination in 10 days. According to author Yang (1983) the seeds of Tilia mongolica treated with 50-200 ppm GA_3 followed by 120 days at lower temperature give 92.5 per cent germination. Pital et al. (1984) reported that GA_3 improved germination of intact seeds of Hob Hornbean (Ostrya virginiana) and resulted in 70-80 per cent germination.

CHAPTER III

MATERIAL AND METHODS

The present investigation entitled "Study on the propagation techniques of some important shrubs" was conducted at the experimental area, Nauni of the Department of Silviculture and Agroforestry, Dr Y.S. Parmar University of Horticulture and Forestry, Solan (H.P) during July, 1988 to August, 1989. The details of the experimental site, materials and methodology used for the study are discussed in this chapter.

3.1 Experimental site

3.1.1 Location

The experimental site lies at Nauni in the mid-hill zone of Himachal Pradesh, located 15 Km. South-East of Solan, latitude 30°50'N and longitude 70°11'E. The elevation being 1200 m above mean sea level.

3.1.2 Climate

The climate of the area ranges between sub tropical to sub temperate with maximum and minimum temperatures experienced being 34°C and -2°C respectively. In general, May and June are the hottest months and December and January the coldest. The area on average receives an annual rainfall of 1150 mm, most of which is concentrated in the monsoon period (June-August).

The meteorological data for the experimental site recorded for the period July, 1988 to August, 1989 are presented in Table 1.

Table 1. Meteorological data for the experimental site during the field studies (July, 1988 to August, 1989)

Month	Temperature(°C)			Relative humidty (%)	Rainfall (mm)	Number of rainy days
	Max.	Min.	Mean			
July,88	28.9	20.2	24.5	81.9	1066.4	22
Aug.,88	28.4	18.9	23.7	79.8	513.4	14
Sept 88	27.4	15.3	21.3	74.8	382.6	11
Oct.,88	25.8	10.3	17.8	55.5	-	-
Nov.,88	21.3	5.8	13.5	68.0	2.0	1
Dec.,88	18.3	3.4	10.8	63.2	166.2	5
Jan.,89	14.8	1.5	8.1	61.4	114.0	5
Feb.,89	17.0	3.5	10.3	42.3	15.0	2
March,89	21.4	7.4	14.3	45.7	52.0	6
April,89	25.7	10.8	18.5	28.8	1.8	1
May,89	31.0	14.8	22.8	31.5	39.2	4
June,89	28.9	17.2	23.0	54.7	120.6	10
July,89	27.9	19.7	23.8	72.1	251.8	8
Aug.,89	26.5	19.0	22.7	80.6	429.3	12

Source: Meteorological observatory, Department of Forest Biology and Tree Improvement, Dr Y.S. Parmar University of Horticulture and Forestry, Solan(HP)

The experiment conducted for the studies are as follows:

3.1 Effects of auxin application on rooting of stem cuttings using auxins in liquid medium method, dip and duration 24 hours

Experiment I: Propagation of *Debregeasia hypoleuca* by stem cuttings under Nursery conditions.

Treatments:
a) Control
IAA Concentrations: 100,400 and 700 ppm
IBA Concentrations: 100,400 and 700 ppm
NAA Concentrations: 100,400 and 700 ppm
b) Seasons: Rainy, Winter and Spring

Experiment II: Propagation of *Coriaria nepalensis* by stem cuttings under Nursery conditions.

Treatments:
a) Control
IAA Concentrations: 100,400 and 700 ppm
IBA Concentrations: 100,400 and 700 ppm
NAA Concentrations: 100,400 and 700 ppm
b) Seasons: Rainy, Winter and Spring

Experiment III: Propagation of *Woodfordia floribunda* by stem cuttings under Nursery conditions.

Treatments:
a) Control
IAA Concentrations: 100,400 and 700 ppm
IBA Concentrations: 100,400 and 700 ppm
NAA Concentrations: 100,400 and 700 ppm
b) Seasons: Rainy, Winter and Spring

Experiment IV: Propagation of *Berberis lycium* by stem cuttings under Nursery conditions.

Treatments: a) Control

IAA Concentrations:100,400 and 700 ppm

IBA Concentrations:100,400 and 700 ppm

NAA Concentrations:100,400 and 700 ppm

3.2 Effect of application of auxins in solid medium on rooting behaviour of stem cuttings. Season premonsoon, mediums used Talc and activated charcoal

Experiment V: Propagation of *Debregeasia hypoleuca* by stem cuttings under Nursery conditions.

Treatments:

T_1 Control

T_2 Talc powder

T_3 Talc powder with 1% IBA

T_4 Talc powder with 0.5% IBA

T_5 Talc powder with 0.25% IBA

T_6 Activated charcoal

T_7 Activated charcoal with 1% IBA

T_8 Activated charcoal with 0.5% IBA

T_9 Activated charcoal with 0.25%

Experiment VI: Propagation of *Coriaria nepalensis* by stem cuttings under nursery conditions.

Treatments:

T_1 Control

T_2 Talc powder

T_3 Talc powder with 1% IBA

T_4 Talc powder with 0.5%

T_5 Talc powder with 0.25% IBA

T_6 Activated charcoal

T_7 Activated charcoal with 1% IBA

T_8 Activated charcoal with 0.5% IBA

T_9 Activated charcoal with 0.25% IBA

Experiment VII: Propagation of *Woodfordia floribunda* by stem cuttings under Nursery conditions.

Treatments:

T_1 Control

T_2 Talc powder

T_3 Talc powder with 1% IBA

T_4 Talc powder with 0.5% IBA

T_5 Talc powder with 0.25% IBA

T_6 Activated charcoal

T_7 Activated charcoal with 1% IBA

T_8 Activated charcoal with 0.5% IBA

T_9 Activated charcoal with 0.25% IBA

Experiment VIII: Propagation of *Berberis lycium* by stem cuttings under Nursery conditions.

Treatments:

T_1 Control

T_2 Talc powder

T_3 Talc powder with 1% IBA

T_4 Talc powder with 0.5% IBA

T_5 Talc powder with 0.25% IBA

T_6 Activated charcoal

T_7 Activated charcoal with 1% IBA

T_8 Activated charcoal with 0.5% IBA

T_9 Activated charcoal with 0.25% IBA

The treatments in all the above experiments were replicated three times.

The details of method used and techniques adopted for propagation of the stem cuttings are given below:

Propagation of stem cuttings:

Cuttings were obtained from ten randomly selected shrubs of comparable vigour from plants selected in the proximity of experimental site. The dimensions and description of cuttings drawn being length 20 to 25 cm and diameter 0.75 to 1.00 cm with atleast 2-3 nodes removed from fully mature, one to two years old healthy shoots of selected mother plants. The upper portions of the stem were given a slanting cut after removal.

The prepared cuttings were thereafter immediately removed to the laboratory for treatment with different rooting substances. Prior to application of rooting chemicals the cuttings were divided into three groups according to their diameter for three replications. For every treatment 10 cuttings were taken. The cuttings were tagged and subjected to chemical treatments.

Preparation of IAA, IBA and NAA solutions:

The solutions were prepared by dissolving a calculated quantity of the chemical first in a small amount of ethyl alcohol. The required volume was then made up by adding known quantities of distilled water to prepare a stock solution. The stock solution was diluted to the various known concentrations desired whenever required. Fresh stock solution being used every time.

Preparation of rooting powder formulations:

Rooting powder formulations were prepared as described by H.C. Hare (1973) with talc powder and activated charcoal as the medium and IBA used as rooting hormone in different concentrations. Powder were prepared by dissolving the calculated quantity of IBA first in ethyl alcohol, then making a slurry with talc powder or activated charcoal, evaporating the ethyl alcohol and sifting these rooting powder finally stored in small plastic containers. These were applied to cutting, so as a small quantity adhered to the base.

Treatment of cuttings:

The cuttings were treated with different growth promoting substances by prolonged dip method for 24 hours in case of experiments No.I to IV. The solutions of different concentrations were poured into plastic containers and the cuttings were dipped in the solution upto 3-5 cm depth. After 24 hours period the cuttings were removed to the field for planting. In case of experiments No.V to VIII, cuttings were treated by quick dip method. The rooting powders were applied to cutting bases and soon after treated cuttings planted in the nursery beds.

Planting of the cuttings:

Selection of site and preparation of nursery beds:

A sunny site with sandy loam soil was selected for field planting of cutting. The soil was worked by deep digging twice. A good amount of compost was also mixed thoroughly with the soil. The nursery beds were 3 x 3 m in size. The area was divided into three equal parts along the fertility gradient. One replication was planted in each part.

Planting of stem cuttings:

The treated cuttings were planted 10 cm deep with the help of a planter and spaced at 10 cm in rows, which were placed 15 cms apart. The cuttings in each treatments were ten in number. The cuttings were regularly irrigated on alternate days.

Observations taken after 70 days:

a) Root initiation:

i) Percentage of rooting:

Number of cuttings showing successful root initiation were counted. All the percentage values were transformed by using arc sine transformation as described by Gomez and Gomez (1984).

ii) Number of roots per cutting:

The rooted portion of cuttings was gently washed to expose the roots. The roots were then counted and their number tabulated. The data thus obtained was transformed by using square root transformation as suggested by Gomez and Gomez(1984).

iii) Root lenght:

Length of five longest roots from each cutting was measured with the help of a scale for cutting treated by prolonged dip method and their average was computed. Cuttings treated with rooting powder using quick dip were measured for their root length using a root scanner which was available then for the purpose.

iv) Callus formation:

The unrooted cuttings, showing callus formation were counted in each treatment. The percentage values were then transformed by using arc sine transformation.

b) General condition of the cuttings:

The cuttings were kept under constant observations for their general conditions. They were particularly watched for their general vigour, condition of leaves on the cuttings, sprouting of buds and their subsequent growth behaviour.

3.3 Propagation by seeds

3.3.1 Laboratory studies

Experiment IX: Determination of germination per cent and germination energy of *Debregeasia hypoleuca* in germinator

Treatments:
- T_1 Control
- T_2 Cold water 24 hours
- T_3 Cold water. 48 hours
- T_4 Hot water
- T_5 GA_3 100 ppm 24 hours

Experiment X: Determination of germination per cent and germination energy of *Coriaria nepalensis* in germinator

Treatments:
- T_1 Control
- T_2 Cold water 24 hours
- T_3 Cold water 48 hours
- T_4 Hot water
- T_5 GA_3 100 ppm 24 hours

Experiment XI: Determination of germination per cent and germination energy of *Woodfordia floribunda* in germinator

Treatments:
- T_1 Control
- T_2 Cold water 24 hours
- T_3 Cold water 48 hours

T_4 Hot water

T_5 GA_3 100 ppm 24 hours

Experiment XII: Determination of germination per cent and germination energy of *Berberis lycium* in germinator

Treatments: T_1 Control

T_2 Cold water 24 hours

T_3 Cold water 48 hours.

T_4 Hot water

T_5 GA_3 100 ppm 24 hours

The treatments in all the above experiments were replicated three times.

3.3.2 Nursery studies

Experiment XIII: Seeds were directly sown in the nursery beds during rains and spring season for all shrub species

Experiment XIV:

Seeds were first sown in trays or containers with sand and earth mixture. Seedlings emerging in high density were transplanted as small clump after 30 to 40 days. It was not possible to separate seedlings individually at this stage. The transplanted seedlings clump were possible to separate as individual plants after another 30-40 days and can be pricked out into polythene bags or other containers. Watering was done cautiously with the help of a hand pump and excessive moisture avoided at all stages of seedling development. This experiment was done in case of *Debregeasia*, *Coriaria* and *Woodfordia* on the same lines as Rai et al. (1988) carried out for four species of *Ficus*. The very minute size of the shrub seeds necessitates following this procedure.

A detailed account of method followed and techniques adopted during propagation by seeds is given below:

Collection of seeds:

The seeds were collected from fully ripened but fresh fruits obtained from the mature mother plants in mid June. The fresh fruits were dried in sun for about 10-15 days for easy extraction of shrub seeds particularly for *Berberis* and *Coriaria*. Sun drying was also resorted for *Debregeasia* and *Woodfordia* as otherwise these were found susceptible to fungal infection. On drying and extraction seeds were stored in plastic containers for further studies.

Selection of site and preparation of nursery beds:

A good sunny site with sand loam soil was selected for sowing seeds in the field. Fields were prepared by deep soil working 2-3 times, seiving the soil and adding good amount of compost and sand. Each bed was 1 x 1 m in size with provision for providing shade.

Due to the very minute size, seeds were first mixed with sand and then broadcast on the nursery beds, particularly in case of *Woodfordia*, *Debregeasia* and *Coriaria*. For *Berberis* seeds were covered with small amount of soil. The beds were regularly irrigated.

Observations recorded:

i) Time taken for germination:

The number of days in emergence of seedlings till the last seedlings emerged in the germination/nursery beds/trays.

ii) Germination percentage:

The germination percentage was calculated by number of seeds in a given sample that actually germinated.

iii) Germination energy:

The percentage by number of seeds in a given sample that germinated upto the time when the rates of germination (number of seeds germinating per day) reaches its peak (BCFT).

Statistical analysis

The data recorded for the different parameters were subjected to appropriate statistical analysis as per the procedure given by Cochran and Cox (1970).

CHAPTER IV

EXPERIMENTAL RESULTS

The results on the studies conducted are presented below:

Experiment I: Propagation of *Debregeasia hypoleuca* by stem cuttings under Nursery conditions.

The cuttings were planted in Rainy, Winter and Spring seasons. They were kept under continuous observation and carefully examined after 70 days for their general condition, rooting per cent and callus formation. The experiment indicated the season of cuttings removal and subsequent planting to have bearing on the rooting performance. Cuttings planted in Winter season failed completely to initiate roots, whereas cuttings raised during Rainy and Spring season rooted well. Observations on rooting in winter season being nil, were not included for statistical analysis of the data. The results are summarised below.

(a) Rainy season

i) Per cent success in rooting

Data on rooting per cent of cuttings are presented in Table 2.

A perusal of the data in Table 2 indicates that though all the treatments except T_5 and T_6 increased rooting per cent as compared with control but were all statistically at par with

Table 2. Effect of different treatments of IAA, IBA and NAA during rainy season on rooting of stem cuttings of *Debregeasia hypoleuca* (Mean values)

RAINY SEASON

Treatments	Rooting per cent	Callusing per cent	Number of roots per cutting	Average root length (cm)
T_1 Control	28.78 (23.33)	12.40 (6.67)	7.17	6.78
T_2 IAA 100 ppm	30.99 (26.67)	18.44 (10.00)	11.00*	7.67
T_3 IAA 400 ppm	35.00 (33.33)	21.15 (13.33)	12.95*	9.44*
T_4 IAA 700 ppm	33.00 (30.00)	21.15 (13.33)	13.17*	7.56
T_5 IBA 100 ppm	39.15 (40.00)*	30.99 (26.67)*	21.33*	13.89*
T_6 IBA 400 ppm	47.00 (53.33)*	35.22 (33.33)*	21.67*	16.11*
T_7 IBA 700 ppm	30.99 (26.67)	23.85 (16.67)*	12.39*	8.44*
T_8 NAA 100 ppm	37.22 (36.67)	21.15 (13.33)	19.00*	13.22*
T_9 NAA 400 ppm	33.00 (30.00)	23.85 (16.67)*	13.22*	8.89*
T_{10} NAA 700 ppm	28.78 (23.33)	18.44 (10.00)	10.67*	6.67
SE m ±	4.85	4.17	1.28	0.68
C.D. 5%	10.18	8.75	2.69	1.42

() The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s

Table 2. Effect of different treatments of IAA, IBA and NAA during rainy season on rooting of stem cuttings of <u>Debregeasia hypoleuca</u> (Mean values)

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T_6 IBA 400 ppm	47.00 (53.33)*	35.22 (33.33)*	21.67*	16.11*
T_7 IBA 700 ppm	30.99 (26.67)	23.85 (16.67)*	12.39*	8.44*
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T_9 NAA 400 ppm	33.00 (30.00)	23.85 (16.67)*	13.22*	8.89*
T_{10} NAA 700 ppm	28.78 (23.33)	18.44 (10.00)	10.67*	6.67
SE m ±	4.85	4.17	1.28	0.68
C.D. 5%	10.18	8.75	2.69	1.42

( ) The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s

each other. The best treatment, as adjudged by per cent rooting was IBA 400 ppm. This treatment registered a success of 53.33 per cent followed by IBA 100 ppm with a success of 40 per cent.

ii) Per cent success in callusing of unrooted cuttings

The observations recorded on the callus formation are included in Table 2.

A perusal of the data on callusing in Table indicates that callusing per cent increased with different treatments of IAA, IBA and NAA. But the treatments; T_2, T_3, T_4, T_8 and T_{10} were statistically at par with T_1 (Control). Only treatments T_5, T_6, T_7 and T_9 were statistically superior than control. The best treatment for per cent callusing was IBA 400 (T_6).

iii) Root number

A perusal of the data given in Table 2 reveals that all the treatments significantly increased the root number per cutting compared to control. Maximum number of roots were produced with IBA 400 ppm followed by IBA 100 ppm. Both these treatments were statistically at par with each other.

iv) Average root length

A perusal of data given in Table 2 indicates that IAA, IBA and NAA have significant effect on average root length of cuttings. IBA 400 ppm produced maximum average root length of 16.11 cm and was statistically significant compared to other treatments. The cuttings treated with NAA 700 ppm had the least average root length (6.67 cm) and was statistically at par with control.

(b) Spring season

The data for per cent success in rooting, per cent, success in callusing of unrooted cuttings, root number/cutting and average root length is presented in Table 3.

i) Per cent success in rooting

All concentrations of IBA, IAA and NAA increased the per cent rooting of the cuttings but the values of IAA and NAA were statistically insignificant with each other and control. Cuttings treated with different concentrations of IBA produced significantly higher per cent rooting than control. The statistically superior treatment, as adjudged by per cent rooting was IBA 100 ppm with rooting success of 67.67 per cent.

ii) Per cent success in callusing of unrooted cuttings

The data in Table 3 indicates that though callusing per cent was increased with different concentrations of IAA, IBA and NAA, yet IAA and NAA treatments were statistically at par with control. Like rooting per cent IBA treatments also statistically increased callusing per cent when compared with control. IBA 400 ppm induced maximum callusing of 33.33 per cent.

Table 3. Effect of different treatments of IAA, IBA and NAA during spring season on rooting of stem cuttings of *Debregeasia hypoleuca* (Mean values)

SPRING SEASON

Treatments	Rooting per cent	Callusing per cent	Number of roots per cutting	Average root length (cm)
T_1 Control	30.99 (26.67)*	18.44 (10.00)	10.11	7.44
T_2 IAA 100 ppm	35.22 (33.33)	21.15 (13.33)	16.11*	12.22*
T_3 IAA 400 ppm	39.23 (40.00)	26.07 (20.00)	18.89*	15.44*
T_4 IAA 700 ppm	33.00 (30.00)	21.15 (13.33)	13.33	11.28*
T_5 IBA 100 ppm	54.78 (67.67)*	33.21 (30.00)*	29.89*	20.11*
T_6 IBA 400 ppm	45.00 (50.00)*	35.22 (33.33)*	21.89*	16.89*
T_7 IBA 700 ppm	41.07 (43.33)*	30.78 (26.67)*	18.67*	15.45*
T_8 NAA 100 ppm	35.01 (33.33)	21.15 (13.33)	15.17*	10.83*
T_9 NAA 400 ppm	39.15* (40.00)	26.07 (20.00)	19.22*	15.33*
T_{10} NAA 700 ppm	37.22 (26.67)	23.85 (16.67)	18.89*	12.44*
SE m ±	4.38	4.41	1.78	0.77
C.D. 5%	9.19	9.26	3.74	1.62

() The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s.

iii) Root number

Data given in Table 3 indicates that all the treatments statistically increased number of roots per cutting excepting T_4 as compared with control. In case of T_4 (IAA 700 ppm) though number of roots per cutting increased but remained statistically at par with control. As adjudged by root numbers treatment T_5 i.e. IBA 100 ppm with 29.89 roots per cutting. proved to be superior statistically.

iv) Average root length

Data at Table 3 indicates that all auxins i.e. IAA, IBA and NAA significantly effect increase in root length and average root length in treated cuttings was higher as compared with control. Treatment T_5 i.e. IBA 100 ppm with 20.11 cm root length was statistically superior as adjudged by average root length.

(c) Per cent rooting - seasonal interaction

The data for interaction is presented in Table 4. Data given in the Table indicates that both variables i.e. rooting hormones and seasons of planting had significant effect on the rooting of <u>Debregeasia hypoleuca</u> cuttings. The statistically superior treatments as adjudged by rooting per cent being IBA 100 ppm providing 53.33 per cent rooting followed by IBA 400 ppm providing 51.67 per cent rooting and the season as spring.

Table 4. Effect of different treatments of IAA, IBA and NAA in different season on rooting of stem cuttings of Debregeasia hypoleuca (Mean values)

Seasons	Control	Treatments IAA 100 ppm	IAA 400 ppm	IAA 700 ppm	IBA 100 ppm	IBA 400 ppm	IBA 700 ppm	NAA 100 ppm	NAA 400 ppm	NAA 700 ppm	Mean
S_1 (Rainy)	28.78 (23.33)	30.99 (26.67)	35.00 (33.33)	33.00 (30.00)	39.15 (40.00)	47.00 (53.33)	30.99 (26.67)	37.22 (36.67)	33.00 (30.00)	28.78 (23.33)	34.39 (32.33)
S_2 (Spring)	30.99 (26.67)	35.22 (33.00)	39.23 (40.00)	33.00 (30.00)	54.78 (67.67)	45.00 (50.00)	41.07 (43.33)	35.01 (33.33)	39.15 (40.00)	37.22 (36.67)	39.35* (40.00)
Mean	29.89 (25.00)	33.11 (30.00)	37.12* (36.67)	33.00 (30.00)	49.96* (53.33)	46.00* (51.67)	36.03 (35.00)	36.12 (35.00)	36.07 (35.00)	33.00 (30.00)	36.73 (36.16)

C.D. 5%			SEm ±
	for season	= 2.87	1.42
	for auxin	= 6.43	3.18
	for interaction	= N.S.	4.50

() The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s.

·late I a) Effect of auxin application on rooting of stem cuttings of *Debregeasia hypoleuca* during spring season

b) Effect of IBA application in different powder formulations on the rooting of *Debregeasia hypoleuca* during rainy season

PLATE - 1

A

B

Experiment II: Propagation of *Coriaria nepalensis* by stem cuttings under Nursery conditions

This experiment was conducted on the same lines as Experiment I. Cuttings planted in winter season failed to initiate roots. On the other hand, cuttings planted during the rainy and spring season rooted successfully. The results are summarised below:

(a) Cuttings raised in rainy season

The data for this season is presented in Table 5.

i) Per cent success in rooting

Perusal of data given in Table 5 indicates that treatments with auxins whether IAA, IBA or NAA increased rooting per cent compared to control. Treatments T_2, T_3, T_4, T_7 and T_{10} were statistically at par, whereas T_5, T_6, T_8 and T_9 treatments were statistically superior than control (T_1). The best results as adjudged by per cent rooting were provided by treatment with IBA 100 ppm producing 53.33 per cent rooting, followed by IBA 400 ppm and NAA 400 ppm producing 46.67 per cent rooting.

ii) Per cent callusing of non rooted cuttings

Perusal of data given in Table 5 indicates callusing per cent increased with increasing concentration of IAA,

Table 5. Effect of different treatments of IAA, IBA and NAA during rainy season on rooting of stem cuttings of _Coriaria nepalensis_ (Mean values)

RAINY SEASON

Treatments	Rooting per cent	Callusing per cent	Number of roots per cutting	Average root length (cm)
T_1 Control	30.99 (26.67)	18.44 (10.00)	7.50	2.72
T_2 IAA 100 ppm	33.00 (30.00)	23.85 (16.67)	9.11*	3.56
T_3 IAA 400 ppm	37.22 (36.67)	28.29 (23.33)*	12.44*	4.11*
T_4 IAA 700 ppm	30.99 (26.67)	28.78 (23.33)*	10.28*	4.33*
T_5 IBA 100 ppm	46.92 (53.33)*	37.22 (36.67)*	21.56*	7.67*
T_6 IBA 400 ppm	43.08 (46.67)*	39.15 (40.00)*	15.89*	6.11*
T_7 IBA 700 ppm	39.15 (40.00)	35.22 (33.33)*	13.67*	5.56*
T_8 NAA 100 ppm	41.15 (43.33)*	37.22 (36.67)*	16.22*	6.22*
T_9 NAA 400 ppm	43.08 (46.67)*	37.22 (36.67)*	20.56*	6.67*
T_{10} NAA 700 ppm	35.22 (33.33)	21.15 (13.33)	15.00*	4.22*
SE m ±	3.89	3.92	0.72	0.46
C.D. 5%	8.17	8.23	1.51	0.96

( ) The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s.

whereas with IBA and NAA it exhibited a maximum at intermediate concentrations. The treatments T_2 and T_{10} were statistically at par with T_1 (Control) whereas other treatments being statistically superior compared to control. The best treatment, as adjudged by per cent callusing was IBA 400 ppm followed by IBA 100 ppm, NAA 400 and 100 ppm.

iii) Root numbers

Data in Table 5 indicates all auxin treatments having statistically increased number of roots per cutting compared to control. As adjudged by number of roots per cutting, IBA 100 ppm (T_5) producing an average of 21.56 roots per cutting followed by NAA 400 ppm (T_9) producing an average of 20.56 roots per cutting were statistically at par with each other but statistically significant compared to control.

iv) Average root length

Data given in Table 5 indicates that with all treatments except T_2 (IAA 100 ppm) root length increased significantly. Adjudged by average root length produced IBA 100 ppm which induced 7.67 (cm) of root followed by NAA 400 ppm inducing 6.67 cms of root were found to the statistically significant compared to control.

(b) Performance in spring season

The data for this season is presented in Table 6.

Table 6. Effect of different treatments of IAA, IBA and NAA during spring season on on rooting of stem cuttings of Coriaria nepalensis (Mean values)

SPRING SEASON

Treatments	Rooting per cent	Callusing per cent	Number of roots per cutting	Average root length (cm)
T_1 Control	28.78 (23.33)	12.40 (6.67)	6.67	2.72
T_2 IAA 100 ppm	30.90 (26.67)	21.15 (13.33)	7.33	3.11*
T_3 IAA 400 ppm	35.22 (33.33)	23.85 (16.67)*	8.00*	3.22*
T_4 IAA 700 ppm	41.15 (43.33)*	28.78 (23.33)*	9.67*	4.11*
T_5 IBA 100 ppm	43.08 (46.67)*	33.00 (30.00)*	10.56*	4.89*
T_6 IBA 400 ppm	45.00 (50.00)*	37.22 (36.67)*	11.89*	5.78*
T_7 IBA 700 ppm	38.85 (40.00)*	23.85 (16.67)*	8.78*	4.28*
T_8 NAA 100 ppm	41.15 (43.33)*	28.79 (23.33)*	9.78*	4.22*
T_9 NAA 400 ppm	39.23 (40.00)*	30.99 (26.67)*	9.11*	4.11*
T_{10} NAA 700 ppm	37.22 (36.67)	21.15 (13.33)	8.67*	3.89*
SEm±	4.14	4.53	0.52	0.43
C.D. 5%	8.69	9.51	1.09	0.90

() The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s

i) Per cent rooting

A perusal of data given in Table 6 indicates that rooting per cent increased with increasing concentrations of IAA and decreased with higher NAA concentrations whereas IBA exhibited maximum rooting at medium concentration. The treatments T_2 (IAA 100 ppm), T_3 (IAA 400 ppm) and T_{10} (NAA 700 ppm) were statistically at par with T_1 (Control). The best treatment as adjudged by rooting per cent was T_6 (IBA 400 ppm) inducing 50 per cent rooting followed by T_5 (IBA 100 ppm) with 46.67 per cent rooting.

ii) Per cent callusing in unrooted cuttings

Data given in Table 6 indicates callusing per cent to have increased with application of IAA, IBA and NAA compared to control. The best treatment as adjudged by callusing per cent was T_6 (IBA 400 ppm) with 36.67 per cent callusing followed by T_5 (IBA 100 ppm) with 30.00 per cent callusing and T_9 (NAA 400 ppm) with 26.67 per cent callusing. Treatments T_3, T_4, T_5, T_6, T_7, T_8 and T_9 being statistically significant over control i.e. T_1.

iii)Root number

Data given in Table 6 also indicates that all the treatments except T_2 (IAA 100 ppm) increased average number of roots per cutting to statistically significant levels over control.

Table 7. Effect of different treatment sof IAA, IBA and NAA in different seasons on rooting of stem cuttings of <u>Coriaria nepalensis</u> (Mean values)

Seasons	Control	Treatments									Mean
		IAA 100 ppm	IAA 400 ppm	IAA 700 ppm	IBA 100 ppm	IBA 400 ppm	IBA 700 ppm	NAA 100 ppm	NAA 400 ppm	NAA 700 ppm	
S_1 (Rainy)	30.99 (26.67)	33.00 (30.00)	37.22 (36.67)	30.99 (26.67)	46.92 (53.33)	43.08 (46.67)	39.15 (40.00)	41.15 (43.33)	43.08 (46.67)	35.22 (33.33)	38.08 (38.33)
S_2 (Spring)	28.78 (23.33)	30.99 (26.67)	35.22 (33.33)	41.15 (43.33)	43.08 (46.67)	45.00 (50.00)	38.85 (40.00)	41.15 (43.33)	39.23 (40.00)	37.22 (36.67)	38.07 (38.33)
Mean	29.89 (25.00)	32.00 (28.33)	36.22* (35.00)	36.07* (35.00)	45.00* (50.00)	44.04* (48.33)	39.00* (40.00)	41.15* (43.33)	41.15* (43.33)	36.22* (35.00)	38.07 (38.33)

				SE m ±
C.D. 5%	for season	=	N.S.	1.24
	for auxin	=	5.61	2.77
	for interaction	=	N.S.	3.92

() The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s.

Plate II a) Effect of auxin application on rooting of stem cuttings of *Coriaria nepalensis* during spring season

b) Effect of IBA application in different powder formulations on the rooting of *Coriaria nepalensis* during rainy season

PLATE - II

A

B

The best treatment, as adjudged by number of roots produced per cutting was T_6 (IBA 400 ppm) with 11.89 root numbers per cutting, followed by T_5 (IBA 100 ppm) with 10.56 root number per cutting.

iv) Average root length

Data in Table 6 again indicates that all treatments except T_2 (IAA 100 ppm) and T_3 (IAA 400 ppm) increased root length to statistically significant levels compared to control. The best treatment, as adjudged by average root length being T_6 (IBA 400 ppm), producing 5.78 cm root length followed by T_5 (IBA 100 ppm) producing 4.89 cm root length.

(c) Per cent rooting - seasonal interaction

Season interaction data on rooting per cent is presented in Table 7. A perusal of which indicates that though different rooting hormones significantly effected rooting of Coriaria nepalensis, seasons effect was nonsignificant in this species. The best treatment, as adjudged by rooting per cent was IBA 100 ppm with 50 per cent rooting followed by IBA 400 ppm with 48.33 per cent rooting for both the seasons.

Experiment III: Propagation of Woodfordia floribunda by stem cuttings under Nursery conditions

This experiment was conducted on similar lines as

Table 8. Effect of different treatments of IAA, IBA and NAA during rainy season on rooting of stem cuttings of *Woodfordia floribunda* (Mean values)

	RAINY SEASON			
Treatments	Rooting per cent	Callusing per cent	Number of roots per cutting	Average root length (cm)
T_1 Control	6.37 (3.33)	1.00 (0.00)	1.55 (2.00)	1.17 (0.43)
T_2 IAA 100 ppm	18.44 (10.00)	1.77 (3.33)	2.71 (4.33)	1.55 (1.40)*
T_3 IAA 400 ppm	21.15 (13.33)	2.55 (6.67)	2.77 (6.67)*	1.57 (1.46)*
T_4 IAA 700 ppm	6.37 (3.33)	1.00 (0.00)	1.61 (2.33)	1.18 (0.46)
T_5 IBA 100 ppm	18.44 (10.00)	2.97 (10.00)	2.89 (7.33)*	1.65 (1.72)*
T_6 IBA 400 ppm	30.78 (26.67)*	3.74 (13.33)	3.61 (10.83)*	1.92 (2.68)*
T_7 IBA 700 ppm	21.15 (13.33)	1.77 (3.33)	2.94 (7.67)*	1.69 (1.79)*
T_8 NAA 100 ppm	12.40 (6.67)	2.97 (10.00)	2.30 (5.17)	1.38 (0.99)
T_9 NAA 400 ppm	6.37 (3.33)	3.32 (10.00)	1.61 (2.33)	1.18 (0.46)
T_{10} NAA 700 ppm	0.33 (0.00)	1.77 (3.33)	1.00 (0.00)	1.00 (0.00)
SE m±	7.43	1.02	0.57	0.16
C.D. 5%	15.61	N.S.	1.20	0.34

() The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s

previous experiments. Cuttings planted in winter season failed to initiate roots whereas cuttings raised in rainy and spring seasons rooted only to an extent. The results are summarised under following heads.

(a) Results obtained for cuttings raised in rainy season

, The data for this season is present ed in Table 8.

i) Per cent success in rooting

All treatments except T_6 (IBA 400 ppm) were statistically at par compared to control. Increasing concentrations of IAA and NAA failed to influence rooting significantly. In fact higher concentration of auxins exhibited inhibitory effect on rooting. adjudged by rooting per cent only treatment T_6 (IBA 400 ppm) producing 26.67 per cent rooting was statistically significant over control.

ii) Per cent success in callusing of unrooted cuttings

Data in the same table i.e. 8 indicates the effect of different treatments on callusing per cent as being non significant.

iii) Root number

Column four of Table 8 indicates, treatments T_2 (IAA 100 ppm), T_4 (IAA 700 ppm), T_8 (NAA 100 ppm), T_9 (NAA 400 ppm)

T_{10} (NAA 700 ppm) to be statistically at par compared to control, whereas the remaining T_3, T_5, T_6, T_7, statistically superior compared to control. The best treatment as adjudged by number of roots per cutting being T_6 (IBA 400 ppm) with average 10.83 root numbers per cuttings followed by T_7 (IBA 700 ppm) with 7.67 root numbers per cuttings.

iv) Average root length

Column five of Table 8 indicates treatments T_4 (IAA 700 ppm), T_8 (NAA 100 ppm), T_9 (NAA 400 ppm) and T_{10} (NAA 700 ppm) to be statistically at par compared to control, whereas reaming treatments i.e. T_2, T_3, T_5, T_6 and T_7 being statistically significant compared to control. The best treatment, as adjudged by average root length being T_6 (IBA 400 ppm) with 2.68 cms root length followed by T_7 (IBA 700 ppm) with 1.70 cms root length.

(b) Performance of cuttings in spring season

The data for this season is presented in Table 9.

i) Per cent rooting

A perusal of data in Table 9 indicates that rooting per cent increased with different concentrations of IAA, IBA and NAA compared to control. Treatments T_2 (IAA 100 ppm), T_4 (IAA 700 ppm), T_5 (IBA 100 ppm) and T_{10} (NAA 700 ppm) being

Table 9. Effect of different treatments of IAA, IBA and NAA during spring season on rooting of stem cuttings of *Woodfordia floribunda* (Mean values)

SPRING SEASON

Treatments	Rooting per cent	Callusing per cent	Number of roots per cutting	Average root length (cm)
T_1 Control	18.44 (10.00)	0.33 (0.00)	6.83	1.40
T_2 IAA 100 ppm	23.85 (16.67)	6.37 (3.33)	8.33*	1.77*
T_3 IAA 400 ppm	26.56 (20.00)*	12.40 (6.67)	9.83*	2.37*
T_4 IAA 700 ppm	23.85 (16.67)	12.40 (6.67)	11.94*	2.57*
T_5 IBA 100 ppm	23.85 (16.67)	21.15 (13.33)*	11.00*	2.87*
T_6 IBA 400 ppm	28.78 (23.33)*	21.15 (13.33)*	13.22*	3.03*
T_7 IBA 700 ppm	30.99 (26.67)*	23.85 (16.67)*	13.83*	4.27*
T_8 NAA 100 ppm	33.00 (30.00)*	26.07 (20.00)*	18.83*	6.57*
T_9 NAA 400 ppm	28.78 (23.33)*	21.15 (13.33)*	13.06*	4.87*
T_{10} NAA 700 ppm	23.85 (16.67)*	6.37 (3.33)	8.33*	2.40*
SE m ±	3.57	6.54	0.60	0.10
C.D. 5%	7.50	13.73	1.27	0.22

( ) The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s.

statistically at par compared to control and the remaining treatments i.e. T_3, T_6, T_7, T_8 and T_9 were statistically significant over control. The best treatment as adjudged by per cent rooting was T_8 (NAA 100 ppm) with 30.00 per cent rooting, followed by T_7 (IBA 700 ppm) with 26.67 per cent rooting, T_9 (NAA 400 ppm) and T_6(IBA 400 ppm) with 23.33 per cent rooting.

ii) Per cent callusing in unrooted cuttings

Figures at column three of Table 9 indicates no callusing for T_1 (Control) while all other treatments produced callused cuttings. Treatments T_2 (IAA 100 ppm), T_3 (IAA 400 ppm), T_4 (IAA 700 ppm) and T_{10} (NAA 700 ppm) were at par compared with control whereas the remaining i.e. T_5, T_6, T_7, T_8 and T_9 being statistically significant. The best treatment, as adjudged by per cent of callusing being T_8 (NAA 100 ppm) 20.00 per cent, followed by T_7 (IBA 700 ppm) 16.67 per cent.

iii) Root numbers

Column four of Table 9 indicates all treatments being statistically significant compared to control in initiation of number of roots. The best treatment, as adjudged by number of roots per cutting was T_8 (NAA 100 ppm) with 18.83 roots number per cutting followed by T_7 (IBA 700 ppm) with 13.83 root number, T_6 (IBA 400 ppm) 13.22 root numbers and T_9 (NAA 400 ppm) 13.06 number of roots per cutting.

Table 10 Effect of different treatments of IAA, IBA and NAA in different season on rooting of stem cuttings of <u>Woodfordia floribunda</u> (Mean values)

Seasons	Control	Treatments									Mean
		IAA 100 ppm	IAA 400 ppm	IAA 700 ppm	IBA 100 ppm	IBA 400 ppm	IBA 700 ppm	NAA 100 ppm	NAA 400 ppm	NAA 700 ppm	
S_1 (Rainy)	6.37 (3.33)	18.44 (10.00)	21.15 (13.33)	6.37 (3.33)	18.44 (10.00)	30.78 (26.67)	21.15 (13.33)	12.40 (6.67)	6.37 (3.33)	0.33 (0.00)	14.18 (9.00)
S_2 (Spring)	18.44 (10.00)*	23.85 (16.67)	26.56 (20.00)	23.85 (16.67)*	23.85 (16.67)	28.78 (23.33)	30.99 (26.67)	33.00 (30.00)*	28.78 (23.33)*	23.85 (16.67)*	26.00 (20.00)*
Mean	12.40 (6.67)	21.15 (13.33)*	23.85 (16.67)*	15.11 (10.00)	21.44 (13.33)*	29.78 (25.00)*	26.07 (20.00)*	22.70 (18.33)*	17.57 (13.33)	12.26 (8.33)	20.19 (14.50)

C.D. 5%			SEm ±
for season	=	2.77	1.37
for auxin	=	6.19	3.06
for interaction	=	8.76	4.33

() The values given in the parentheses are the actual values and those outside the parentheses are the transformed values

* Significant at 5 per cent l.o.s.

Plate III a) Effect of auxin application on rooting of stem cuttings of *Woodfordia floribunda* during spring season

b) Effect of IBA application in different powder formulations on the rooting of *Woodfordia floribunda* during rainy season

PLATE - III

A

B

iv) Average root length

Figures at column 5 of Table 9 indicates all treatments to be statistically significant as compared to control. The best treatment, as adjudged by average root length was T_8 (NAA 100 ppm) with 6.57 cms root length, followed by T_9 (NAA 400 ppm) with 4.87 cms root length.

c) Per cent rooting - seasonal interaction

The data on season interaction with hormones is presented in Table 10. A perusal of which indicates that seasons and auxins and their interaction significantly affect rooting per cent. Rooting per cent in Spring i.e. 20.0 per cent was statistically significant compared to rainy season i.e. 9.00 per cent. The best hormonal treatment, as adjudged by rooting per cent was IBA 400 ppm (25.00 per cent), followed by IBA 700 ppm (20.00 per cent) and NAA 100 ppm (18.33 per cent) rooting. Interaction due to season x auxins was also significant in case of T_1 (Control), T_4 (IAA 700 ppm), T_7 (IBA 700 ppm), T_8 (NAA 100 ppm), T_9 (NAA 400 ppm) and T_{10} (NAA 700 ppm).

Experiment IV: Propagation of *Berberis lycium* by stem cuttings under Nursery conditions.

This experiment was conducted on similar line as previous experiments. Cuttings planted failed to initiate

Plate IV   Rooted cuttings of *Berberis lycium* during spring season

PLATE - IV

roots irrespective of season. Only spring planted cuttings produced some callusing in treatments with various concentrations of IBA solutions, but were statistically non significant compared to control. The spring season trials also failed to produce roots except for two cuttings rooted successfully, one with T_5 (IBA 100 ppm) and another with T_6 (IBA 400 ppm). Statistical analysis is for <u>Berberis lycium</u> was therefore not carried out.

<u>Powder formulation in Talc powder & Activated charcoal</u>

<u>Experiment V</u>: Propagation of <u>Debregeasia hypoleuca</u> by stem cuttings under nursery conditions during rainy season using powder formulations

The cuttings with these treatments were raised only during rainy season. They were tended carefully and examined after 70 days for their general condition, rooting per cent, callus formation, root number and length. The data for this experiment is presented in Table 11.

i) Per cent success in rooting

A perusal of column 2 in Table 11 indicates that all the treatments increased rooting per cent as compared to control. Treatments, T_2 (talc powder), T_3 (talc powder with 0.25 per cent IBA), T_5 (talc powder with 1 per cent IBA), T_6 (activated charcoal) and T_7 (activated charcoal with 0.25 per cent IBA) were all at par with T_1 (Control). The best

Plate V Sprouted cuttings in nursery beds during rainy season

PLATE- V


DEBREGEASIA HYPOLEUCA


CORIARIA NEPALENSIS


WOODFORDIA


BERBERIS LYCIUM

Table 11. Effect of IBA application in different powder medium on the rooting of <u>Debregeasia hypoleuca</u> during rainy season

RAINY SEASON

Treatments	Rooting per cent	Callusing per cent	Number of root per cutting	Total root length (cm)
T_1 Control	28.78 (23.33)	12.40 (6.67)	7.17	30.00
T_2 Talc powder	33.21 (30.00)	23.85 (16.67)	12.11*	96.67*
T_3 Talc with 0.25% IBA	35.22 (33.33)	21.15 (13.33)	24.00*	150.00*
T_4 Talc with 0.5% IBA	43.07 (46.67)*	21.15 (13.33)	26.00*	170.00*
T_5 Talc with 1% IBA	30.99 (26.67)	21.15 (13.33)	12.83*	50.00*
T_6 Activated charcoal	33.21 (30.00)	23.85 (16.67)	11.50*	36.67*
T_7 Activated charcoal with 0.25% IBA	33.00 (30.00)	23.85 (16.67)	15.72*	66.67*
T_8 Activated charcoal with 0.5% IBA	37.22 (36.67)*	30.99 (26.67)	21.67*	116.67*
T_9 Activated charcoal with 1% IBA	52.77 (63.33)*	23.85 (16.67)	26.67*	206.67*
SEm±	3.12	4.63	0.48	5.49
C.D. 5%	6.61	N.S	1.02	11.64

() Figures in parentheses are actual values and those outside are transformed values

* Significant at 5 per cent l.o.s.

treatment, as adjudged by per cent success in rooting was T_9 (activated charcoal with 1 per cent IBA) producing 63.33 per cent rooting, followed by T_4 (talc powder with 0.25 per cent IBA) with 46.67 per cent rooting.

ii) Per cent success in callusing

Figure at column 3 of Table 11 indicate though all treatments increased callusing per cent as compared with control but the results were statistically non significant.

iii) Root numbers

Figure at column 4 of Table 11 indicates all treatments to have significantly increased the number of roots per cutting compared with T_1 (Control). The best treatment, as adjudged by number of roots per cutting was T_9 (activated charcoal with 1 per cent IBA) 26.67 number of roots per cutting, followed by T_4 (talc powder with 0.5 per cent IBA) 26.00 number of roots per cutting. Both treatments T_9 and T_4 were statistically at par with each other but statistically significant compared to other treatments.

iv) Total root length

Column five of Table 11 indicates all treatments to be statistically significant over control and showing marked increases in total root length produced. The best treatment, as adjudged by total root length was T_9(activated charcoal with 1 per cent IBA) 206.67 cm total root length, followed by T_4 (talc powder with 0.5 per cent IBA) 170.00 cm total root length.

Experiment VI: Propagation of *Coriaria nepalensis* by stem cuttings under nursery conditions during rainy season using powder formulations

i) Rooting per cent

Figures at column 1 Table 12 indicates that all treatments except T_5 (talc powder with 1 per cent IBA) increased rooting per cent. In treatment T_5 rooting per cent was less than control. Treatments; T_2 (talc powder), T_4 (talc powder with 0.5 per cent IBA), T_5 (Talc powder with 1 per cent IBA), T_6 (activated charcoal) and T_9 (activated charcoal with 1 per cent IBA) did not differ significantly from control, whereas T_3 (talc powder with 0.25 per cent IBA), T_7 (activated charcoal with 0.25 per cent IBA) and T_8 (activated charcoal with 0.5 per cent IBA) were statistically significant to T_1 (control). T_8 (activated charcoal with 0.5 per cent IBA) produced maximum rooting (56.67 per cent), followed by T_3 (talc powder with 0.25 per cent IBA) with 50.00 per cent rooting and T_7 (activated charcoal with 0.25 per cent IBA) 40.00 per cent rooting.

ii) Per cent callusing in non rooted cuttings

Data at column 2 Table 12 indicates, though all the treatments increased callusing per cent of non rooted cutting yet the results were non significant.

Table 12. Effect of IBA application in different powder medium on the rooting of *Coriaria nepalensis* during rainy season

Treatments	Rooting per cent	Callusing per cent	Number of root per cutting	Total root length (cm)
	RAINY SEASON			
T_1 Control	30.99 (26.67)	18.44 (10.00)	7.83	33.33
T_2 Talc powder	33.21 (30.00)	23.85 (16.67)	10.44*	33.33
T_3 Talc with 0.25% IBA	45.00 (50.00)*	26.56 (20.00)	19.88*	46.67*
T_4 Talc with 0.5% IBA	35.22 (33.33)	20.56 (20.00)	15.33*	36.67
T_5 Talc with 1% IBA	28.78 (23.33)	23.85 (16.67)	11.33*	26.67
T_6 Activated charcoal	35.21 (33.33)	21.15 (13.33)	11.67*	26.67
T_7 Activated charcoal with 0.25% IBA	39.14 (40.00)*	23.85 (16.67)	19.33*	56.67*
T_8 Activated charcoal with 0.5% IBA	48.85 (56.67)*	26.56 (20.00)	21.78*	93.33*
T_9 Activated charcoal with 1% IBA	33.21 (30.00)	28.78 (23.33)	6.17	10.00
SE m ±	3.32	2.89	0.70	4.58
C.D. 5%	7.04	N.S	1.48	9.71

() Figures in parentheses are actual values and those outside are transformed values

* Significant at 5 per cent l.o.s.

iii) Root numbers

Formulations of IBA both in Talc powder and activated charcoal at all concentrations increased the root number and values were significantly higher over control with the exception of T_9 (activated charcoal with 1 per cent IBA). T_9 produced least root number (6.17) and was only 1.66 less than T_1 (control). Production of roots were in the order, treatment T_8 (activated charcoal with 0.5 per cent IBA) (maximum) followed by T_3 (talc powder with 0.25 per cent IBA), T_7 (activated charcoal with 0.25 per cent IBA), T_4 (talc powder with 0.5 per cent IBA), T_6 (activated charcoal), T_5 (talc powder with 1 per cent IBA), T_2 (talc powder), T_1 (control) and T_9 (activated charcoal with 1 per cent IBA).

iv) Total root length

Data at column five of Table 12 indicates reducation in total root length in treatments T_5 (talc powder with 1 per cent IBA), T_6 (activated charcoal) and T_9 (activated charcoal with 1 per cent IBA) compared to T_1 (control). The total root length exhibibited significant increases over control in treatments T_3 (talc powder with 0.25 per cent IBA), T_7 (activated charcoal with 0.25 per cent IBA) and T_8 (activated charcoal with 0.5 per cent IBA). T_8 produced a maximum total root length of 93.33 cms.

Experiment VII: Propagation of *Woodfordia floribunda* by stem cuttings under nursery conditions during rainy season using powder formulations

The data for per cent rooting, callusing per cent of non rooted cuttings, number of roots/cutting and total root length is given in Table 13.

i) Per cent rooting

Data on per cent rooting (column 2) indicates that all the treatments except T_4 (talc powder with 0.5 per cent IBA) and T_5 (talc powder with 1 per cent IBA) were statistically at par with each other. The best treatment, as adjudged by rooting per cent being T_5 with 26.67 per cent rooting followed by T_4 with 20.00 per cent rooting. Rooting per cent in T_4 and T_5 mutually at par were statistically significant over all others treatments.

ii) Per cent callusing in non rooted cuttings

Per cent callusing of non rooted cuttings (column 3 Table 13) improved with increased concentrations of IBA in both media. The increase was more in talc powder than activated charcoal indicating a synergestic effect of talc powder on rooting in cuttings. Maximum callusing 26.67 per cent of non rooted cutting in talc powder medium was found in T_5 (with 1 per cent IBA), followed by T_4 (with 0.5 per cent IBA), T_3 (with 0.25 per cent IBA) and T_2 (talc powder). In activated

Table 13. Effect of IBA application in different powder medium on the rooting of *Woodfordia floribunda* during rainy season

RAINY SEASON

Treatments	Rooting per cent	Callusing per cent	Number of root per cutting	Total root length (cm)
T_1 Control	6.37 (3.33)	0.33 (0.00)	1.55 (2.00)	1.77 (3.33)
T_2 Talc powder	6.37 (3.33)	21.15(13.33)*	1.61 (2.33)	1.77 (10.00)
T_3 Talc with 0.25% IBA	12.40 (6.67)	26.56 (20.00)*	2.28 (5.00)	3.00 (10.00)
T_4 Talc with 0.5% IBA	26.56 (20.00)*	28.78 (23.33)*	3.83 (14.00)*	5.24 (26.67)*
T_5 Talc with 1% IBA	30.99 (26.67)*	30.99 (26.67)*	4.20 (16.67)*	5.57 (30.00)*
T_6 Activated Charcoal	0.33 (0.00)	0.33 (0.00)	1.00 (0.00)	1.00 (0.00)
T_7 Activated charcoal with 0.25% IBA	6.37 (3.33)	12.40 (6.67)*	1.55 (2.00)	1.77 (3.33)
T_8 Activated charcoal with 0.5% IBA	12.40 (6.67)	15.11 (10.00)*	2.44 (6.00)	3.00 (10.00)
T_9 Activated charcoal with 1% IBA	12.40 (6.67)	23.85 (16.67)*	2.49 (6.33)	3.39 (13.33)
SEm ±	7.46	5.41	0.79	1.15
C.D. 5%	15.82	11.47	1.67	2.44

() Figures in parentheses are actual values and those outside are transformed values

* Significant at 5 per cent l.o.s.

charcoal medium T_9 (with 1 per cent IBA) produced maximum callusing (16.67 per cent) followed by T_8 (with 0.5 per cent IBA), T_7 (with 0.25 per cent IBA) and T_6 (activated charcoal). All the treatments except T_6 were statistically significant over control.

iii) Root number

Root number per cutting (column 4 Table 13) also increased with increasing concentration of IBA in both media as is evident from the data. The best among the tried treatments was T_5 (ralc powder with 1 per cent IBA) followed by T_4 (talc powder with 0.5 per cent IBA), T_9 (activated charcoal with 1 per cent IBA), T_8 (activated charcoal with 0.5 per cent IBA), T_3 (talc powder with 0.25 per cent IBA), T_2 (talc powder), T_7 (control) and T_6 (activated charcoal), T_6 and T_4 treatments produced significantly greater root number of 4.20 and 3.83 respectively than control. All other treatments being statistically at par with each other.

iv) Total root length

Data on total root length (column 5 Table 13) exhibits the same rising pattern with increased concentration of IBA formulations in talc powder and activated charcoal. T_5 (talc powder with 1.00 per cent IBA) and T_4 (talc powder with 0.5 per cent IBA) produced significantly higher total root length over remaining treatments. All other treatments being statistically non significant. A maximum total root length of 5.57 cm was observed in treatment T_5.

Experiment VIII: Propagation of Berberis lycium by stem cuttings under nursery conditions using powder formulations

Though a large number of cuttings sprouted initially but failed to initiate root. Statistical analysis for the species was therefore not possible.

Experiment IX: Determine the germination per cent and germination energy of Debregeasia hypoleuca seeds in germinator(Appendix I-IV)

With hot water treatment seeds completely failed to germinate. This treatment was therefore not included in the statistical analysis of the data. The data for germination per cent and germination energy is presented in Table 14 column 2 and Table 15 column 2 respectively. Data given in Table 14 indicates that treatments T_1 (control), T_2 (cold water 24 hours) and T_3 (cold water 48 hours) were at par with each other. Only treatment T_4 (GA 100 ppm 24 hours) significantly increased germination per cent (96.33 per cent) compared to control (72.33 per cent).

Data at Table 15 indicates germination energy to have significantly increased in all treatments as compared to T_1

(control) with 36.00 per cent germination energy. The best treatment, as adjudged by germination energy was T_4 (GA 100 ppm 24 hours) indicating 49.67 per cent germination energy followed by T_2 (cold water 24 hours) with 43.24 per cent germination energy.

Table 14. Effect of pre-sowing treatments on germination per cent of *Debregeasia*, *Coriaria* and *Woodfordia* seeds

Treatments	Species		
	Debregeasia hypoleuca	*Coriaria nepalensis*	*Woodfordia floribunda*
T_1 Control	58.28 (72.33)	54.55 (66.33)	51.36 (61.00)
T_2 Cold water 24 hours	56.80 (70.00)	54.86 (66.67)	66.41 (83.67)*
T_3 Cold water 48 hours	57.23 (70.67)	54.14 (65.67)	67.77 (85.67)*
T_4 GA 100 ppm 24 hours	79.04 (96.33)*	65.96 (83.33)*	49.99 (58.67)
SE m ±	1.57	2.38	2.54
C.D. 5%	3.84	5.84	6.22

() Figures in parentheses are actual values and those outside parentheses are transformed values

* Significant at 5 per cent l.o.s.

Experiment X: Determine the germination per cent and germination energy of *Coriaria nepalensis* seeds in germinator (Appendix V-VIII)

Seeds treated with hot water at boiling point did not germinate and as such this treatment was not included in statistical analysis. Data for germination per cent and germination energy are presented in Table 14 and 15 column three respectively. Data of Table 15 indicates that treatments T_1 (control), T_2 (cold water 24 hours) and T_3 (cold water 48 hours) were at par with each other. Only in case of T_4 (GA 100 ppm 24 hours) germination per cent was significantly increased (83.33 per cent).

Table 15 Effect of pre-sowing treatments on germination energy of *Debregeasia*, *Coriaria* and *Woodfordia* seeds

Treatments	Species		
	Debregeasia hypoleuca	*Coriaria nepalensis*	*Woodfordia floribunda*
T_1 Control	36.87 (36.00)	35.48 (34.00)	32.69 (27.67)
T_2 Cold water 24 hours	43.24 (46.67)*	40.16 (38.33)	41.72 (44.33)
T_3 Cold water 48 hours	40.57 (42.33)*	41.36 (43.66)	43.46 (47.33)
T_4 GA 100 ppm 24 hours	44.81 (49.67)*	41.68 (44.33)	35.03 (33.00)
SEm ±	1.25	5.73	3.93
C.D. 5%	3.07	N.S	N.S

() Figures in parentheses are actual values and those outside parentheses are transformed values

* Significant at 5 per cent l.o.s.

Germination energy in *Coriaria nepalensis* was maximum in T_4 (GA 100 ppm 24 hours) but all treatments were statistically at par with each other.

Experiment XI: Determination of germination per cent and germination energy of *Woodfordia floribunda* seeds in germinator (Appendix X-XII)

In this experiment also hot water treated seeds did not germinate and thus the treatment was omitted from the statistical analysis. The data for germination per cent is presented in Table 14, whereas for germination energy in Table 15. A perusal of data given in Table 16 indicates that treatments T_1 (control) and T_4 (GA 100 ppm 24 hours) were at par with each other. In T_4 (GA 100 ppm 24 hours) germination per cent was slightly lower than T_1 (control). In the treatments T_2 (cold water 24 hours) and T_3 (cold water 48 hours) germination per cent significantly increased as compared to T_1 (control). The best treatment, as adjudged by germination per cent was T_3 (cold water 48 hours) with 85.67 per cent germination followed by T_2 (cold water 24 hours) with 83.67 per cent germination and both the treatments were statistically at par with each other.

A perusal of the data given in Table 15 indicates that results for germination energy in case of *Woodfordia floribunda* were non significant.

Experiment XII: Germination per cent and germination energy of *Berberis lycium* in the germinator (Appendix XIII)

In this case seeds treated with different pre-sowing treatments on paper top failed to germinate in the germinator. The statistical analysis for germination per cent and germination energy was therefore not possible. To determine germination energy and germination per cent seeds of *Berberis lycium* were sown in nursery beds without pre-sowing treatments. Germination per cent for *Berberis lycium* was found to be 59 per cent and germination energy as 33 per cent .

Experiment XIII: Seeds of all shrubs species included in the study directly sown in the nursery beds during rainy season and spring season

The seeds of most shrub species are very minute. On sowing they germinated easily in the nursery beds but die soon due to damping off especially in *Woodfordia floribunda*, *Coriaria nepalensis* and *Debregeasia hypoleuca* species. The minute seed size creates difficulties in regulating irrigation i.e. optimum moisture levels resulting in severe infection by pathogens resulting in damping off seedlings. *Berberis lycium* seeds are comparatively very large and germinated more easily in nursery beds but were yet found susceptible to fungal infections resulting in high mortality upto 40 days when a very few seedlings had survived, which were uprooted and transplanted in polythene begs for their further growth.

Plate VI a) *Debregeasia hypoleuca* seedlings in container after one month of sowing

b) *Coriaria nepalensis* seedlings in container in clump after first transplanting

PLATE- VI

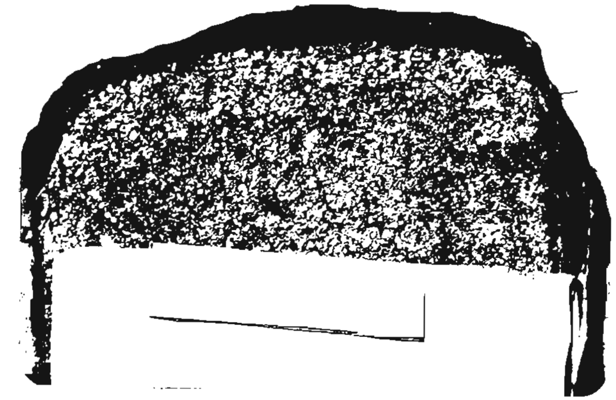
A

B

...sis nyct...ca seedlings in container after one ... sowing

...oriaria ne...nsis seedlings in container in clump after ... transplanting

PLATE- VI



A

B

Experiment XIV:

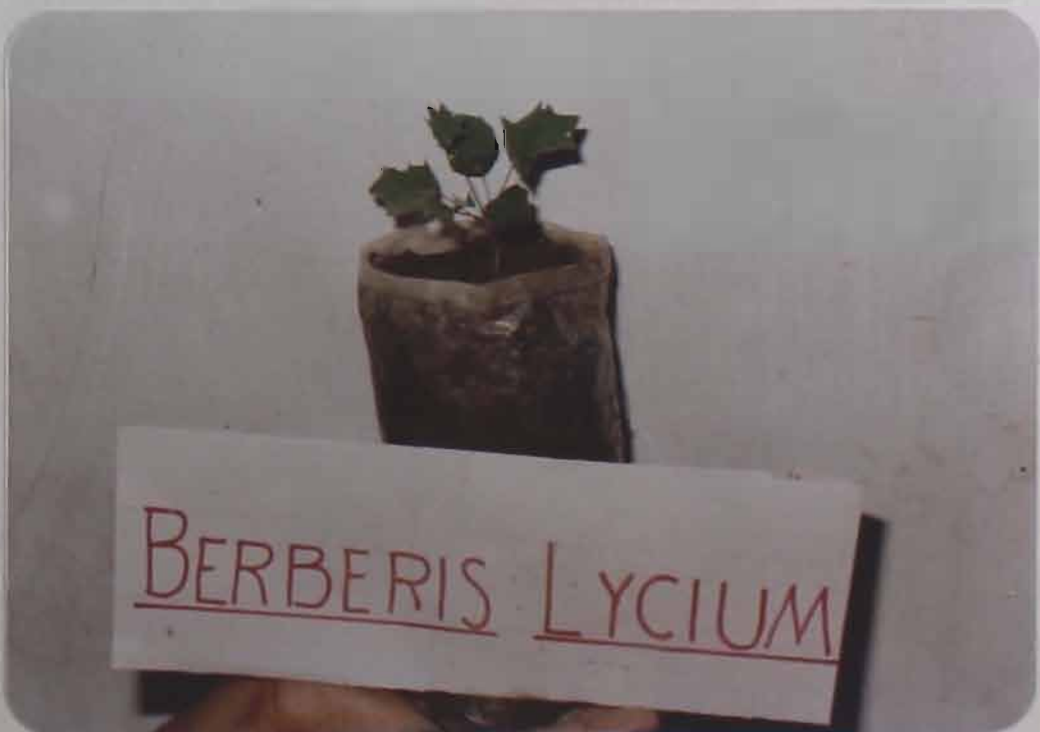
In another experiment the seeds of *Woodfordia floribunda*, *Coriaria nepalensis* and *Debregeasia hypoleuca* were sown in containers filled with earth and sand mixture. The irrigation was done with the help of small hand pump and to check pathogen attack on newly emerged sprays of Bavestine 0.1 per cent concentration at 15 days intervals carried out. Inspite, seedlings of *Woodfordia floribunda* did not survive beyound 20 days, whereas *Coriaria nepalensis* seedlings indicated improved survival and were transplanted in containers as seedling clumps after 35 days. Transplanting is indicated in steps due to delicateness of seedling which emerge in very high density. A second transplanting was done in polythene bags after one month for their further growth. *Debregeasia hypoleuca* seedlings as survived were similarly tranplanted after 40 days into containers in clumps. A second transplanting done in polythene bags after one month.

Plate VII a) *Woodfordia floribunda* seedlings in trays after 20 days of sowing

b) Seedling of *Berberis lycium* in polythene bag

PLATE - VII

A

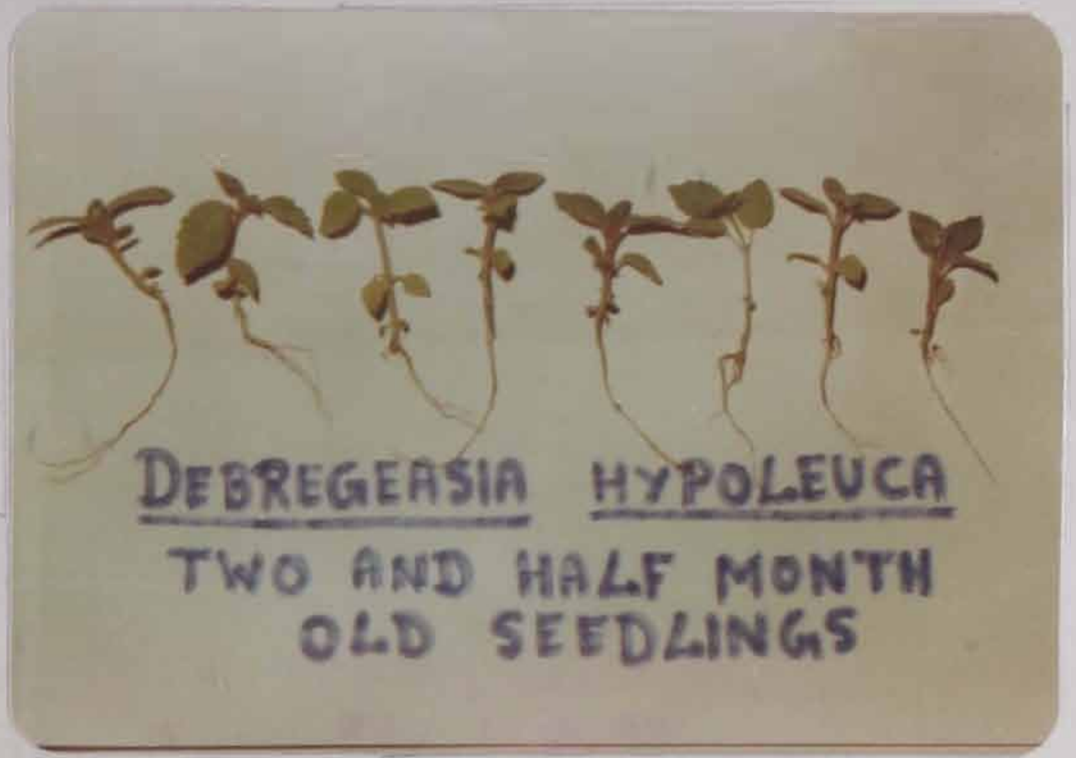


B

Plate VIII a) Two and half month old seedlings of *Debregeasia hypoleuca*

b) Two and half month old seedlings of *Coriaria nepalensis*

PLATE - VIII



A

B

DISCUSSION

The results of present investigations, "Study on the propagation techniques of some important shrubs" are being discussed below:

A. Propagation by stem cuttings:

5.1 *Debregeasia hypoleuca*

The results of the present studies indicate that the vegetative propagation of this species was possible by stem cuttings, but the cuttings have to be planted in specific seasons and these do not root all the year round even under nursery conditions. Particularly during winter season cuttings fail completely due to low temperature and severe frost resulting in the inactivity of the cambium which becomes dormant. Though the stem cuttings of this species rooted easily during rains and spring seasons but the results reveal that spring was the best season for rooting (Table 4). In both the seasons treatments T_5 (IBA 100 ppm) and T_6 (IBA 400 ppm) proved better than others. The conclusions as based on the two seasons indicate that IBA at lower concentration i.e. 100 ppm provide best results with 53.33 per cent rooting obtained by prolonged dip for 24 hours. This was followed by IBA 400 ppm with 51.67 per cent rooting. It may be concluded that increase of IBA concentration reduces rooting potential of the species. The optimum limits of IBA concentrations for promoting rooting in Debregeasia hypoleuca stem cuttings are indicated between 0-400 ppm and the method as prolonged dip for 24 hours.

The effect of auxins in enhancing root initiation of stem cuttings confirm the findings of earlier research workers (Thimann and Went, 1934; Cooper, 1936; Hartmann,1946; Leopold, 1960; Karmer, 1966; Nanda et al., 1970; Gupta and Chandra,1978; Hinesley and Blazich, 1980; Negi et al., 1982; Lahiri, 1983; Wise et al., 1985; Puri and Shamet, 1988; Pal, 1989). Numerous reports indicate IBA to be the effective auxin in enhancing root initiation (Nanda et al., 1968; Barry and Sachs, 1968; Nanda et al., 1970; Eggens et al., 1972; Lowery, 1980; Pain and Roy, 1981; Negi and Tewari, 1984; Chandra and Yadava, 1986; Shamet and Kumar, 1988). Rooting success in cuttings of 2 year old seedlings of Gmelina arborea with application of IBA (100 ppm) was observed by Zakaria and Ong (1982). Deolle and Mitchell (1964) reported that spring was the best season for rooting of stem cuttings of many forest trees. Roberts and Fuchigami (1973) reported Feb-March as ideal period for rooting of stem cuttings of Douglas fir.

5.2 Coriaria nepalensis

The results of the present studies indicate possibilities of vegetative propagation of this species by stem cuttings.

The cuttings raised in spring and rainy season provide equally good results but fail to root in the winter season. Failure to root during winter may be assigned to dormancy induced by low temperatures (Table 7). For the two favourable seasons treatments T_5 (IBA 100 ppm) and T_6 (IBA 400 ppm) proved better than other treatments. The conclusion drawn is that IBA at low concentration of 100 ppm applied by the prolonged dip method result in maximum rooting success of 50 per cent. This was closely followed by IBA 400 ppm with 48.33 per cent rooting. The optimum limit of IBA for promoting rooting in *Coriaria nepalensis* stem cuttings appear to lie between 0-400 ppm. The references to support these findings are same as given for *Debregeasia hypoleuca* cuttings. Marygina (1968) reported that stem cuttings of *Picea abies* rooted best when taken from the mother plant in early spring before the bud break or in mid summer after the cessation of extension growth.

5.3 *Woodfordia floribunda*

The results of rooting trials with stem cuttings of this species indicate as rooting success in specific reasons but not all the year around. Particularly during winter season cuttings failed completely due to non condusive weather conditions like low temperatures and frost which induce lowering of physiological activity in plants. The stem cuttings rooted easily in rainy and spring seasons but spring was found the best season for rooting (Table 10). Carbohydrates reserves held by the plant during spring may have resulted in the improved rooting percentage obtained for the season. For rainy season treatment T_6 (IBA 400 ppm) proved best compared to other treatments whereas in case of spring season treatment T_8 (NAA 100 ppm) proved better than other treatments. The conclusion being that treatment T_6 (IBA 400 ppm) resulting in maximum 25 per cent rooting was the optimum level of auxin concentration applied through prolonged dip. This was followed by treatment T_7 (IBA 700 ppm) with 20 per cent rooting. It may be concluded that optimum limits of IBA concentrations for promoting rooting in Woodfordia floribunda stem cuttings lie between 100 to 700 ppm.

Bahuguna et al. (1988) reported that the application of IBA at 200 ppm concentration for 24 hours, best promote rooting of branch cuttings of Woodfordia fructicos during monsoon season. Sunderan et al. (1983) observed 80 per cent rooting in Bambusa arundinacea cuttings treated with 200 ppm NAA. Ye (1984) studied the effect of plant growth regulators on rooting of many broad leaved and coniferous trees and reported IBA and NAA (100 and 200 ppm) were most effective in increasing rooting.

5.4 Berberis lycium

The present investigations reveals the ineffectiveness of auxins in initiation of roots in Berberis lycium irrespective of season. Two out of 300 cuttings raised during spring manifested roots as also callus formation to an extent was observed with cuttings treated with IBA.

Parmar and Khamu (1989), while working on the sexual and asexual propagation of the Indian Barberay (Berberis aristata DC) also failed to obtain rooting in IBA treated cuttings planted in June and July. He, however, obtained 35.5 per cent success while trying to propagate this species by air layering in July using 5000 ppm IBA. The rooting of air layers of this species indicate the rooting potential in Berberis. Possibly the cuttings require some specific conditions for root initiation, to be discovered.

The hard-to-root behaviour of this species may be assigned to either, some anatomical barriers present in the cuttings or the absence of some rooting co-factors, as reported by various workers for such plants (Hess, 1959, 1964, 1965, 1968; Challenger et al., 1965; Lanphear and Meahl, 1961). Another possible reason may be the presence of some rooting inhibitor which are also reported to prevent root initiation (Spiegel, 1955; Gesto et al., 1967; Fadl and Hartmann, 1967).

5.5 Effect of IBA application in different powder medium during rainy season on rooting

The results of present studies reveal that Debregeasia hypoleuca, Coriaria nepalensis and Woodfordia floribunda showed good regenerative capacity or rooting per cent when propagated through stem cuttings treated with varying IBA concentrations in talc powder and activated charcoal mediums. <u>Berberis lycium</u> cuttings without exception failed completely to initiate roots irrespective of different treatments.

In case of <u>Debregeasia hypoleuca</u> treatment T_9 i.e. Activated charcoal with 1% IBA proved significantly better than all other treatments with 63.33 per cent rooting success. This was followed by treatment T_4 i.e. Talc with 0.5% IBA with 46.67 per cent rooting success, but in case of treatment T_5 i.e. Talc with 1% IBA, rooting per cent decreased significantly and was 26.67 per cent. Talc proved a better medium with 0.5% IBA as compared to activated charcoal with 0.5% IBA, whereas in case of 1% IBA rooting success decreased significantly in talc medium whereas it increased as significantly for activated charcoal medium. The optimum limit of IBA concentration in talc medium ranged from 0.25% to 1% whereas in case of activated charcoal it ranged from 0.5% to more than 1%. This may be due to the fact that there is more synergistic response between IBA and the talc powder as compared with IBA and the activated charcoal. Cunningham and Buijtenen (1983) reported that the higher rooting percentages in girdled slash pine shoots obtained by the addition of IBA to the rooting powder treatment may be the result of IBA alone or a synergistic response between IBA and the rooting powder supplement i.e. talc powder.

It is, therefore, suggested that future trials on rooting of stem cuttings should restrict use of IBA in concentrations between 0.25% to 1% with talc medium and 0.5% to 1% for activated charcoal medium.

In case of Coriaria nepalensis treatment T_8 i.e. activated charcoal with 0.5% IBA proved better than all other treatments resulting in 56.67 per cent rooting. This was followed by treatment T_3 i.e talc with 0.25% IBA providing 50 per cent rooting, but in treatment T_4 i.e. talc with 0.5% IBA, rooting per cent decreased significantly and reduced to 33.33 per cent. The conclusion being that talc is a more effective medium with IBA concentration at0.25 per cent as compared to activated charcoal with 0.25% IBA, whereas in case of 0.5% IBA rooting success decreased significantly in talc medium and increased significantly with activated charcoal as medium. The optimum limit of IBA percentage in talc medium ranged from 0% to 0.5% whereas in case of activated charcoal it ranged from 0.25% to 1%. This may be attributed to the higher synergistic response between IBA and talc powder as compared with IBA and activated charcoal.

It is, therefore, suggested that future trials on the rooting of stem cuttings be carried out with IBA percentages between 0% to 0.5% in talc medium and 0.25 to 1% for activated charcoal medium.

In case of <u>Woodfordia floribunda</u> treatments T_5 i.e. talc powder with 1% IBA proved the best resulting in 26.67 per cent rooting, followed by treatment T_4 i.e. talc with 0.5% IBA providing 20 per cent rooting. In activated charcoal medium differing concentrations of auxins exhibited non significant increases in rooting per cent in this species. Cuttings treated exclusively with activated charcoal failed completely in their response to rooting or callusing. Conclusions being that talc was a superior medium for initiation of rooting as compared to activated charcoal for <u>Woodfordia floribunda</u>. The optimum limit of IBA concentrations in talc medium ranged from 0.5% to less than 1%, whereas in case of activated charcoal it may exceed 1 per cent. The reasons attributed are the same as for <u>Debregeasia hypoleuca</u> and <u>Coriaria nepalensis</u>. Cunningham and Buijtenen (1983) reported that rooting success increased significantly when stem cuttings of slash pine treated with a rooting powder (Talc) containing 1 or 2% IBA. They also concluded that success was encouraging when the stems were girdled and treated with a rooting powder containing 1 or 2% IBA for 2 weeks. When 2% IBA was used in rooting powder significantly more primary roots were initiated then with the other auxin treatments. Hare (1974 and 1978) conducted successful experiments on rooting of slash pine cuttings treated with special rooting powder containing 1% IBA and other components.

It is, therefore, suggested that future trials on the rooting of stem cuttings of Woodfordia floribunda should be carried out with IBA concentrations ranging between 0.5% to 1% for talc medium and the results may be further improved by initial shoot girdling followed by removal of the girdled shoot as stem cuttings.

B. Propagation through seeds:

5.6 Debregeasia hypoleuca

The results reveal maximum germination 96.33 per cent obtained with seeds pre-treated with GA_3 100 ppm for 24 hours tested in germinator, while no significant difference observed with other treatments as adjudged by germination per cent (Table 14). The germination per cent of untreated seed being 72.33. Maithani et al. (1989) reported 74 per cent germination in red colour seeds of Debregeasia velutina in the laboratory. Germination energy of Debregeasia hypoleuca seed was also significantly increased in all the treatments as compared with control but was highest with treatment T_4 i.e. GA_3 100 ppm for 24 hours at 49.67 per cent and energy period being 8 days. Dahab et al. (1979) reported that soaking of seeds of Pistacia khinjuk Stocks in GA_3 at 0, 100 and 150 ppm for 24 hours increased the germination percentage from 18 to between 76 and 96 per cent. Carpenter and Smith (1981) reported that the seeds of Paulownia tomentosa treated with GA_3 germinated sooner and reached 98 per cent germination in 10 days. According to Yang (1983) the seeds of Tilia mongolica treated with 50-200 ppm GA_3 followed by storage for 120 days at low temperatures give 92.5 per cent germination. Pital et al. (1984) reported that GA_3 improved germination of intact seeds of Hop-Hornbean (Ostrya virginiana) and resulted in 70-80 per cent germination.

The germination per cent of Debregeasia hypoleuca seeds being good it was directly sown in nursery beds without any pre-treatment. Minute and delicate seedlings emerged on the surface of nursery beds but perished within one month possibly due to excessive moisture inducing damping off pathogens. In an other experiment results reveal that seedlings can be successfully raised in container irrigated with help of small hand pump alongwith fungicidal spray Bavestine (0.1%) at 15 days intervals. Finding, also indicate seeds of Debregeasia hypoleuca seeds to be susceptible to fungi infection especially during monsoons. The parasitic fungi species from infected seeds was identified largely as Alternaria sp. with other saprophytic fungi.

5.7 Coriaria nepalensis

The results reveal a maximum germination of 83.33 per cent in seed obtained in germinator on treatment with GA_3 100 ppm for 24 hours, while significant difference not observed in other treatments as adjudged by germination per cent (Table 15).

The germination per cent for untreated seed was 61 per cent. Maithani et al. (1989) reported little success with attempts on germinating *Coriaria viburnum*, *Vitex lonicera*, *Cotoneaster*, *Crtaegus* and *Rubus* seeds in laboratory and in nursery. The germination energy of *Coriaria nepalensis* seeds did not differ significantly with treatments being at par with each other and for control germination energy was observed as 34 per cent. The conclusions drawn from the finding are that GA_3 100 ppm applied for 24 hours was the best presowing treatment for *Coriaria nepalensis*. The references which are given for *Debregeasia hypoleuca* also support this finding.

The results of the direct sowing of seeds in nursery beds reveal that after germination the seedling failed completely to establish. The reason is attributed to damping off diseases either borne on soil or uncontrolled irrigation. In an other experiment results reveal that seedlings can be successfully raised in containers with controlled irrigation provided with help of spray pump followed by Bavestine (0.1%) spray at 15 days interval.

5.8 *Woodfordia floribunda*

Seeds treated with cold water for 48 hours provided the maximum germination of 85.67 per cent in a germinator and was at par with cold water treatment for 24 hours showing 83.67 per cent germination, while there was no significant difference among other two treatments. Treatment with GA_3 100 ppm for 24 hours resulted in 58.67 per cent germination which was less than control, indicating that GA_3 100 ppm was toxic to the minute seeds of Woodfordia floribunda. Possibly GA_3 at lower concentrations than 100 ppm may be useful in increasing the germination in Woodfordia floribunda. Maithani et al (1989) reported 62 per cent germination in Woodfordia fructicosa seed in the laboratory. The germination energy of Woodfordia floribunda seeds was found non significant with different pre-treatments applied, though germination energy was higher for cold water treatment for 24 hours and 48 hours treatments.

The results of direct sowing in nursery beds and also in containers reveal that seedlings completely fail to establish in both the cases due to damping off diseases and difficulties in controlling irrigation. Maithani et al. (1989) have also arrived at similar findings. Bavestine sprays (0.1%) at 15 days interval seedlings were not helpful in establishing seedlings even in containers. Raising of Woodfordia floribunda seedlings through seeds require very exacting conditions and a sophisticated technique which may not be cost effective in the present circumstances

CHAPTER VI

SUMMARY

The results of the present investigations "Study on the propagation techniques of some important shrubs" are summarised below:

1. *Debregeasia hypoleuca*

a) Rooting was found to be highly influenced by season of raising cuttings. The spring raised cuttings registered maximum rooting of 67.67 per cent with application of 100 ppm IBA. Concentration of IBA, higher than 100 ppm when used in spring decreased rooting percentage.

b) Stem cuttings also rooted well in rainy season and registered a maximum rooting of 53.33 per cent with 400 ppm of IBA. Stem cuttings raised in winter season completely failed.

c) The cuttings of this species exhibited good rooting per cent when treated with different powder formulations with varying percentages of IBA. A maximum rooting of 63.33 per cent with activated charcoal having 1 per cent IBA was registered during rainy season.

d) The results showed that the treatment soaking of seed in GA 100 ppm 24 hours was significantly better providing

96.33 germination per cent than all other treatments. In case of germination energy the treatment GA 100 ppm 24 hours proved better than other treatments, but no significant differences between treatments GA 100 ppm 24 hours and cold water 24 hours were observed.

e) The results showed that the direct sowing of seeds in nursery beds did not give fruitful results and the raising of nursery stock of seedlings of this species will require controlled moisture levels in seed trays and prevention from infection by pathogens.

2. Coriaria nepalensis

a) In this species both spring and rainy seasons provided an equally good rooting per cent in cuttings. Conclusions are drawn that for both seasons IBA 100 ppm (50.00 per cent rooting) were best treatment as compared to others. This was closely followed by IBA 400 ppm providing 48.33 per cent rooting.

b) Cuttings without exceptions failed completely to initiate roots during winter season.

c) The cuttings exhibited a good rooting per cent when treated with different powder formulations with varying concentrations of IBA. A maximum rooting of 56.67 per cent was registered in rainy season with activated charcoal having 0.5 per cent IBA, followed by 50.00 per cent rooting with talc powder with 0.25 per cent IBA.

d) The results show that seed treatment with GA 100 ppm 24 hours was significantly better producing 83.33 per cent germination than any other treatment. The results of germination energy for the species were non-significant which was found as 34.00 per cent for control.

e) Direct sowing of seeds in nursery beds did not provide fruitful results probably seed trays with controlled moisture and adequate measures against pathogen attack may provide results.

3. <u>Woodfordia floribunda</u>

a) Rooting was observed to be linked with season and the spring planted cuttings register a maximum rooting (30.00 per cent with NAA 100 ppm). Concentrations of NAA higher than 100 ppm, decreased the rooting per cent in spring.

b) Stem cuttings also rooted successfully in rainy season and registered a maximum rooting of 26.67 per cent with 400 ppm IBA. The cuttings failed completely to initiate roots in winter season.

c) The cuttings of this species showed good rooting per cent when treated with talc powder formulations of varying percentages of IBA. A maximum rooting of 26.67 per cent with talc powder having 1 per cent IBA was registered during rainy season.

d) The results show that the treatments, cold water 48 hours and cold water 24 hours significantly better than others providing respectively 85.67 and 83.67 per cent germination. The results for germination energy of this species were non significant, germination energy of 47.33 per cent observed in cold water treatment for 48 hours.

e) Usual nursery practices do not help in producing seedlings from seed, special techniques require to be developed for success and pathogen attack needs to be controlled. The problem lie with the minuteness of seed and its susceptibility to even slight excess of moisture coupled with pathogens.

4. Berberis lycium

a) Root formation in the cuttings was difficult irrespective of season, only two cuttings rooted successfully in spring season. Some callus formation takes place in cuttings planted during spring season.

b) The stem cuttings of this species also failed to root completely with usage of powder formulations of varying percentages of IBA during rainy season.

c) The results showed that the seeds of this species decayed on paper top even in the germinator due to excessive moisture and deptren maggots present inherently in seeds. Germination in tray exhibited satisfactory germination, 59 per cent germination and germination energy as 33 per cent when sown without pre-treatment.

e) The results showed that the direct sowing of seeds in nursery beds gives better result in this case but further studies are needed to obtain fruitful results.

The present investigations were of preliminary nature and require further investigations before the propagation techniques of these shrub species may be standardised and practiced.

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Debregeasia hypoleuca

Control

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Comulative total as % of total seeds	Mean daily germination %
1	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–
5	–	3	2	5	5	1.67	0.33
6	2	4	3	9	14	4.67	0.78
7	3	6	8	17	31	10.33	1.48
8	9	7	11	27	58	19.33	2.42
9	21	16	13	50	108	36.00	4.00
10	8	10	12	30	138	46.00	4.60
11	4	2	4	10	148	49.33	4.48
12	2	6	3	11	159	53.00	4.42
13	4	5	4	13	172	57.33	4.41
14	6	4	1	11	183	61.00	4.36
15	4	3	–	7	190	63.33	4.22
16	–	2	2	4	194	64.67	4.04
17	3	1	3	7	201	67.00	3.94
18	1	1	3	5	206	68.67	3.82
19	2	2	–	4	210	70.00	3.68
20	1	2	–	3	213	71.00	3.55
21	–	1	1	2	215	71.66	3.41
22	2	–	–	2	217	72.33	3.29
Total	72	75	70	217			

Mean Germination % = $\frac{72+75+70}{300} \times 100 = \frac{217}{3} = 72.33\%$

Germination Energy = $\frac{5+9+17+27+50}{300} \times 100 = \frac{108}{3} = 36\%$

Energy period = 9 days

Appendix II

Debregeasia hypoleuca

Cold water 24 hours

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Comulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	1	-	1	2	2	0.67	0.17
5	1	2	3	6	8	2.67	0.53
6	6	7	5	18	26	8.67	1.44
7	10	11	9	30	56	18.67	2.67
8	17	11	12	40	96	32.00	4.00
9	15	11	18	44	140	46.67	5.86
10	12	14	9	35	175	58.33	5.83
11	2	4	5	11	186	62.00	5.64
12	2	3	3	8	194	64.67	5.39
13	1	1	2	4	198	66.00	5.08
14	1	1	1	3	201	67.00	4.79
15	2	-	-	2	203	67.67	4.51
16	-	1	1	2	205	68.33	4.27
17	1	-	-	1	206	68.67	4.04
18	-	1	-	1	207	69.00	3.83
19	-	-	1	1	208	69.33	3.65
20	1	-	-	1	209	69.67	3.48
21	-	-	1	1	210	70.00	3.33
Total	72	76	71	210			

Mean Germination % $= \frac{72+67+71}{300} \times 100 = \frac{210}{3} = 70\%$

Germination Energy $= \frac{2+6+18+30+40+44}{300} \times 100 = \frac{140}{3} = 46.67\%$

Energy period = 9 days

Appendix III

Debregeasia hypoleuca

Cold water 48 hours

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Comulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	1	-	-	1	1	0.33	0.08
5	3	-	2	5	6	2.00	0.40
6	6	-	5	11	17	5.67	0.95
7	8	2	6	16	33	11.00	1.57
8	9	5	8	22	55	18.33	2.29
9	18	29	25	72	127	42.33	4.70
10	9	11	12	32	159	53.00	5.30
11	2	4	4	10	169	56.33	5.12
12	1	2	-	3	172	57.33	4.78
13	-	1	1	2	174	58.00	4.46
14	-	2	1	3	177	59.00	4.21
15	2	2	1	5	182	60.67	4.04
16	-	3	2	5	187	62.33	3.96
17	2	2	-	4	191	63.67	3.75
18	1	4	-	5	196	65.33	3.63
19	2	2	2	6	202	67.33	3.54
20	1	2	2	5	207	69.00	3.45
21	2	2	1	5	212	70.67	3.37
Total	67	73	72	212			

Mean Germination % $= \frac{67+73+72}{300} \times 100 = \frac{212}{3} = 17.67\%$

Germination Energy $= \frac{1+5+11+16+22+72}{300} \times 100 = \frac{127}{3} = 42.33\%$

Energy period = 9 days

Appendix IV

Debregeasia hypoleuca

GA 100 ppm 24 hours

Days after putting in germinator	Sub samples A	Sub samples B	Sub samples C	Daily total	Cumulative total	Comulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	2	-	1	3	3	1.00	0.25
5	3	1	2	6	9	3.00	0.60
6	8	7	9	24	33	11.00	1.83
7	12	11	14	37	70	23.33	3.33
8	26	29	24	79	149	49.67	6.21
9	10	9	12	31	180	60.00	6.67
10	8	5	10	23	203	67.67	6.76
11	11	11	6	28	231	77.00	7.00
12	7	3	2	12	241	81.00	6.75
13	1	1	1	3	246	42.00	6.31
14	1	1	-	2	248	82.67	5.91
15	2	6	4	12	260	86.67	5.78
16	4	4	2	10	270	90.00	5.63
17	1	4	-	5	275	91.67	5.39
18	-	1	5	6	281	93.67	5.20
19	-	-	1	1	282	94.00	4.95
20	-	1	-	1	283	94.33	4.72
21	-	2	1	3	286	95.33	4.54
22	-	-	1	1	287	95.67	4.35
23	1	1	-	2	289	96.33	4.19
Total	97	97	95	289			

Mean Germination % $= \frac{97+97+95}{300} \times 100 = \frac{289}{3} = 96.33\%$

Germination Energy $= \frac{3+6+24+37+79}{300} \times 100 = \frac{149}{3} = 49.67\%$

Energy period = 9 days

Appendix V

Coriaria nepalensis

Control

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Cumulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	3	2	3	8	8	2.67	0.38
8	7	5	6	18	26	8.66	1.08
9	14	4	8	26	52	17.33	1.92
10	22	12	16	50	102	34.00	3.40
11	9	10	11	30	132	44.00	4.00
12	3	6	5	14	146	48.67	4.05
13	1	2	1	4	150	50.00	3.85
14	1	2	2	5	155	51.67	3.69
15	2	3	2	7	162	54.00	3.60
16	1	2	3	6	168	56.00	3.50
17	1	4	1	6	174	58.00	3.41
18	3	6	-	9	183	61.00	3.38
19	-	3	3	6	189	63.00	3.31
20	2	1	1	4	193	64.33	3.21
21	1	2	2	5	198	66.00	3.14
22	-	-	1	1	199	66.33	3.01
Total	70	64	65	199			

Mean Germination % $= \frac{70+64+65}{300} \times 100 = \frac{199}{3} = 66.33\%$

Germination Energy $= \frac{8+18+26+50}{300} \times 100 = \frac{102}{3} = 34\%$

Energy period = 10 days

Appendix VI

Coriaria nepalensis

Cold water 24 hours

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Cumulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	2	3	1	6	6	2.00	0.33
7	17	12	10	39	45	15.00	2.14
8	31	19	20	70	115	38.33	4.79
9	12	9	10	31	146	48.67	5.41
10	6	3	5	14	160	53.33	5.33
11	1	6	4	11	171	57.00	5.18
12	1	2	1	4	175	58.33	4.86
13	2	-	3	5	180	60.00	4.61
14	-	1	1	2	182	60.67	4.33
15	2	2	-	4	186	62.00	4.13
16	1	-	1	2	188	62.67	3.92
17	-	2	-	2	190	63.33	3.73
18	-	1	1	2	192	64.00	3.56
19	1	1	-	2	194	64.67	3.40
20	-	-	2	2	196	65.33	3.27
21	-	2	-	2	198	66.00	3.14
22	-	2	-	2	200	66.67	3.03
Total	76	65	59	200			

Mean Germination % $= \frac{76+65+59}{300} \times 100 = \frac{200}{3} = 66.67\%$

Germination Energy $= \frac{6+39+70}{300} \times 100 = \frac{115}{3} = 38.33\%$

Energy period = 8 days

Appendix VII

Coriaria nepalensis

Cold water 48 hours

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Cumulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	1	5	1	7	7	2.33	0.47
6	5	5	5	15	22	7.33	1.22
7	18	15	21	54	76	25.33	3.62
8	20	16	19	55	131	43.67	5.46
9	4	7	4	15	146	48.67	5.41
10	1	2	-	3	149	49.67	4.97
11	3	3	2	8	157	52.33	4.76
12	-	3	2	5	162	54.00	4.50
13	1	-	2	3	165	55.00	4.23
14	-	2	1	3	168	56.00	4.00
15	1	1	2	4	172	57.33	3.82
16	2	-	1	3	175	58.33	3.65
17	-	2	2	4	179	59.67	3.51
18	3	1	-	4	183	61.00	3.39
19	2	-	2	4	187	62.33	3.28
20	-	1	3	4	192	63.66	3.18
21	3	-	-	3	194	64.67	3.07
22	1	1	1	3	197	65.67	2.99
Total	65	64	68	197			

$$\text{Mean Germination \%} = \frac{65+64+68}{300} \times 100 = \frac{197}{3} = 65.67\%$$

$$\text{Germination Energy} = \frac{7+15+54+55}{300} \times 100 = \frac{131}{3} = 43.67\%$$

Energy period = 8 days

Appendix VIII

Coriaria nepalensis

GA 100 ppm 24 hours

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Cumulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	1	1	1	3	3	1.00	0.14
8	2	2	11	15	18	6.00	0.75
9	10	11	16	37	55	18.33	2.04
10	17	20	41	78	133	44.33	4.43
11	19	18	6	43	176	58.67	5.33
12	10	5	2	17	193	64.33	5.36
13	1	1	-	2	195	65.00	5.00
14	3	2	1	6	201	67.00	4.79
15	4	4	1	9	210	70.00	4.67
16	3	2	1	6	216	72.00	4.50
17	3	2	2	7	223	74.33	4.37
18	8	4	2	14	237	79.00	4.39
19	-	2	1	3	240	80.00	4.21
20	2	2	1	5	245	81.67	4.08
21	1	3	-	4	249	83.00	3.95
22	-	1	-	1	250	83.33	3.79
Total	84	80	86	250			

Mean Germination % $= \frac{84+80+86}{300} \times 100 = \frac{250}{3} = 83.33\%$

Germination Energy $= \frac{3+15+37+78}{300} \times 100 = \frac{133}{3} = 44.33\%$

Energy period = 10 days

Appendix IX

Woodfordia floribunda

Control

Days after putting in germinator	Sub samples A	B	C	Daily total	Comulative total	Comulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	1	1	2	2	0.67	0.22
4	9	12	11	32	34	11.33	5.55 (2.83)
5	14	17	18	49	83	27.67	5.53
6	9	10	13	32	115	38.33	6.39
7	8	8	7	23	138	46.00	6.57
8	7	6	3	16	154	51.33	6.42
9	4	4	4	12	166	55.33	6.15
10	3	3	1	7	173	57.67	5.77
11	2	2	1	5	178	59.33	5.39
12	1	-	-	1	179	59.67	4.97
13	-	1	-	1	180	60.00	4.62
14	1	-	1	2	182	60.67	4.33
15	-	-	-	-	182	60.67	4.04
16	-	-	1	1	183	61.00	3.81
Total	58	64	61	183			

Mean Germination % $= \frac{58+64+61}{300} \times 100 = \frac{183}{3} = 61\%$

Germination Energy $= \frac{2+32+49}{300} \times 100 = \frac{83}{3} = 27.67\%$

Energy period = 5 days

Appendix X

Woodfordia floribunda

Cold water 24 hours

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Cumulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	3	2	1	6	6	2.00	1.00
3	14	10	9	33	39	13.00	4.33
4	38	24	32	94	133	43.33	10.83
5	17	18	19	54	187	62.33	12.47
6	5	10	8	23	210	70.00	11.67
7	4	7	5	16	226	75.33	10.76
8	5	5	3	13	239	79.67	9.96
9	1	-	2	3	242	80.67	8.96
10	2	1	-	3	245	81.67	8.17
11	1	-	1	2	247	82.33	7.48
12	-	-	-	-	247	82.33	6.86
13	-	1	1	2	249	83.00	6.38
14	-	-	1	1	250	83.33	5.95
15	-	-	1	1	251	93.67	5.58
Total	90	78	83	251			

$$\text{Mean Germination \%} = \frac{90+78+83}{300} \times 100 = \frac{251}{3} = 83.67\%$$

$$\text{Germination Energy} = \frac{6+33+54}{300} \times 100 = \frac{133}{3} = 44.33\%$$

Energy period = 4 days

Appendix XI

Woodfordia floribunda

Cold water 48 hours

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Cumulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	6	10	4	20	20	6.67	3.33
3	12	25	18	55	75	25.00	8.33
4	22	22	23	67	142	47.33	11.83
5	15	12	11	38	180	60.00	12.00
6	12	4	7	23	203	67.67	11.28
7	8	3	2	13	216	72.00	10.29
8	6	6	9	21	237	79.00	9.88
9	2	1	-	3	240	80.00	8.89
10	-	-	6	6	246	82.00	8.00
11	-	1	1	2	248	82.67	7.52
12	2	-	-	2	250	83.33	6.94
13	-	1	1	2	252	84.00	6.46
14	1	-	1	2	254	84.67	6.05
15	-	1	-	1	255	85.00	5.67
16	-	-	1	1	256	85.33	5.33
17	-	1	-	1	257	85.67	5.04
Total	86	87	84	257			

Mean Germination % $= \frac{86+87+84}{300} \times 100 = \frac{257}{3} = 85.67\%$

Germination Energy $= \frac{20+55+67}{300} \times 100 = \frac{142}{3} = 47.33\%$

Energy period = 4 days

Appendix XII

Woodfordia floribunda

GA 100 ppm 24 hours

Days after putting in germinator	Sub samples A	B	C	Daily total	Cumulative total	Cumulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	5	7	3	15	15	5.00	1.67
4	7	11	9	27	42	14.00	3.50
5	18	20	19	57	99	33.00	6.60
6	6	5	7	18	117	39.00	6.50
7	5	7	9	21	138	46.00	6.57
8	8	6	8	22	160	53.33	6.67
9	4	2	3	9	169	56.33	6.26
10	1	1	1	3	172	57.33	5.73
11	1	-	-	1	173	57.67	5.24
12	1	-	-	1	174	58.00	4.83
13	-	-	1	1	175	58.33	4.49
14	-	-	1	1	176	58.67	4.19
15	1	-	-	1	177	59.00	3.93
16	1	-	-	1	178	59.33	3.71
Total	58	59	61	178			

Mean Germination % $= \frac{58+59+61}{300} \times 100 = \frac{178}{3} = 59.33\%$

Germination Energy $= \frac{15+27+57}{300} \times 100 = \frac{99}{3} = 33\%$

Energy period = 5 days

Appendix XIII

Berberis lycium

Control in trays under nursery condition

Days after sowing in nursery	Sub samples A	B	C	Daily total	Cumulative total	Cumulative total as % of total seeds	Mean daily germination %
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	4	2	3	9	9	3.00	0.33
10	8	4	5	17	26	8.67	0.86
11	18	27	28	73	99	33.00	3.00
12	14	11	12	37	136	45.33	3.77
13	7	8	7	22	158	52.67	4.05
14	3	3	4	10	168	56.00	4.00
15	2	2	1	5	173	57.66	3.84
16	2	-	-	2	175	58.33	3.64
17	-	-	-	-	175	58.33	3.43
18	1	-	1	2	177	59.00	3.27
Total	59	57	61	177			

Mean Germination % $= \frac{59+57+61}{300} \times 100 = \frac{177}{3} = 59\%$

Germination Energy $= \frac{9+17+73}{300} \times 100 = \frac{99}{3} = 33\%$

Energy period = 11 days

- Plant propagation
- Shrubs
- T