

**Status and Propagation of Alder (*Alnus* spp.)  
Tree in Kashmir Valley**

**ARSHAD AHMAD LALA**  
(2006-For-17-M)



**Faculty of Forestry**  
**Faculty of Postgraduate Studies**  
**Sher-e-Kashmir University of Agricultural Sciences &  
Technology of Kashmir**

**2010**

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***THESIS***

**Submitted to**

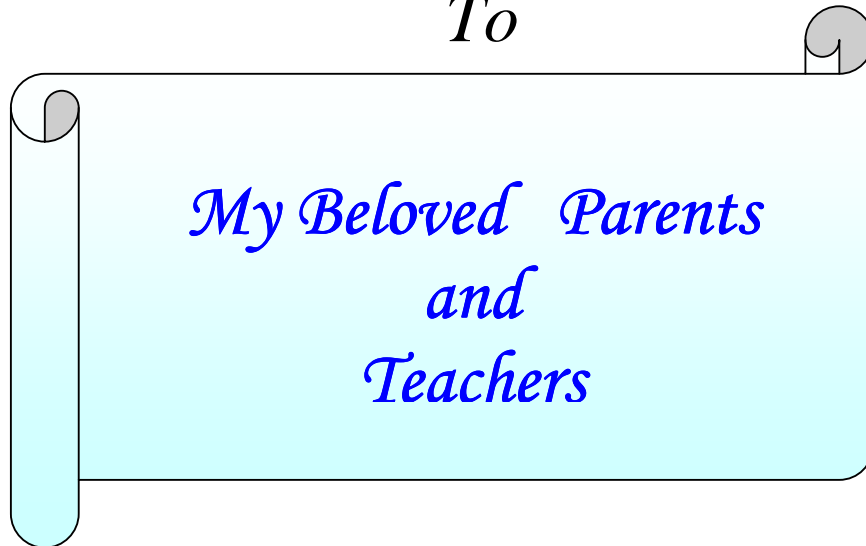
**The Faculty of Postgraduate Studies  
Sher-e-Kashmir  
University of Agricultural Sciences & Technology of Kashmir in  
partial fulfilment of requirement for the award of the degree of**

**MASTER OF SCIENCE IN FORESTRY**

**2010**



*To*



*My Beloved Parents  
and  
Teachers*

**Sher-e-Kashmir**  
**University of Agricultural Sciences & Technology of Kashmir**  
**Faculty of Forestry, Shalimar Campus, Srinagar**

-:o:-

**Certificate – I**

This is to certify that the thesis entitled “**Status and Propagation of Alder (*Alnus spp.*) Tree in Kashmir Valley**” submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Forestry**, to the Faculty of Postgraduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, is a record of bonafide research work carried out by **Mr. Arshad Ahmad Lala (Regd. No. 2006-For-17-M)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

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**CERTIFICATE – II**

We, the members of the Advisory committee of **Mr. Arshad Ahmad Lala (Regd. No. 2006-For-17-M)**, a candidate for the degree of **Master of Science in Forestry**, have gone through the manuscript of the thesis entitled, “**Status and Propagation of Alder (*Alnus* spp.) Tree in Kashmir Valley**” and recommend that it may be submitted by the student in partial fulfilment of the requirements for the award of degree.

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**CERTIFICATE – III**

This is to certify that the thesis entitled, “**Status and Propagation of Alder (*Alnus spp.*) Tree in Kashmir Valley**” submitted by **Mr. Arshad Ahmad Lala (Regd. No. 2006-For-17-M)** to the Faculty of Postgraduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, in partial fulfilment of the requirements for the award of the degree of **Master of Science in Forestry** was examined and approved by the Advisory Committee and external examiner on .....

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Tree in Kashmir Valley”**

**Abstract**

The studies were carried out at the Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar during the year 2007 and 2009. Alder is one of the most important broad leaved tree species of Himalayas but in Kashmir valley its presence is scanty. Only one alder species has been reported in the valley. Since no systematic information was available with respect to this tree species under Kashmir conditions, therefore a research project entitled “Status and Propagation of Alder (*Alnus* spp) tree in Kashmir valley” was undertaken to study its status, distribution and propagation.

A detailed survey conducted at village level of all the districts of Kashmir valley revealed that the tree was found growing only in Srinagar district. On the basis of morphological and phenological characteristics studied in detail, it was found that only one species i.e. *Alnus nitida* Endl. was growing in the Kashmir valley and that too has become endangered. It is commonly known as West Himalayan Alder and locally as *Champ*.

Studies further revealed that only three old living *Alnus nitida* Endl. trees existed in the Kashmir valley and are located in the Harwan area of Srinagar. The average age of these old trees was worked out to be about 127 years with approximate average girth and average height of 180 cm and 35 metres, respectively.

Although the jurisdiction of the study was limited to Kashmir valley but an attempt was also made to locate the tree in moist temperate monsoon regions of Jammu and Kashmir state. The tree was found growing extensively on the banks of river Chenab.

Maturity indices studies conducted to determine the best time for collection of sound seeds from the trees for raising seedlings revealed that seeds get ripened when cone shaped fruit becomes brown and attains cone weight equal to 2.43 g. At maturity seed coat colour turns shiny brown, have specific gravity equal to 0.727, 1000-seed weight equal to 3.2 g and exhibit maximum germination percentage of 42 per cent. Therefore, cone and seed coat colour should be considered as an important index of maturity. The cones/seed should thus be collected in the month of December more specifically by the end of December when fruit/seed coat turns brown.

No dormancy was observed in mature seeds, however, the seeds exhibited very low percentage of purity.

Raising of seedling nursery of *Alnus nitida* Endl. in open beds and root trainers after soaking in water for 24 hours revealed that seedlings performed significantly better with respect to certain characteristics in open beds rather than root trainers. The root length, collar diameters and root shoot ratio showed significantly better results in open beds as compared to root trainers however germination percentage, survival and shoot height showed results at par in either condition.

The tree species is not vegetatively propagated therefore studies were conducted to evaluate the scope of vegetative propagation for this tree species under Kashmir conditions. Studies on vegetative propagation of West Himalayan Alder through stem cuttings revealed that hardwood dormant cuttings after preconditioning and treatment with plant growth regulators in aqueous solution @ 700 ppm gave significant results with respect to rooting.

On the basis of studies conducted it was concluded that cocktail of IBA and NAA each @ 700 ppm was the best plant growth hormone to be used for vegetative propagation of West Himalayan Alder under prevailing conditions. It increased rooting percentage by six times as compared to IAA and two times as compared to IBA and NAA individually at the same concentration. However, softwood cuttings did not respond to plant growth regulators.

**Key words :** *Alnus nitida*, propagation, phenological characters, dbh, specific gravity, percentage purity, plant growth regulator

Signature of Student  
Dated : \_\_\_\_\_

Signature of Major Advisor  
Dated: \_\_\_\_\_

## ACKNOWLEDGEMENT

ALL PRAISE TO ALMIGHT ALLAH, THE MOST GRACIOUS, CHARITABLE, MERCIFUL AND THE MOST BENEFICIENT WHO GAVE ME ENOUGH COURAGE AND VALIANCY TO BRING OUT THIS MANUSCRIPT

*I rejoice to express with profound sense of gratitude and indebtedness, sincere thanks to the most able and considerate chairman of the Advisory Committee – Dr. M.A. Khan, Dean, Faculty of Forestry, SKUAST-K, Shalimar for his uninterrupted guidance, sustained interest and incessant encouragement during the entire course of work. Without his sincere cooperation and supervision this manuscript would not have been reality.*

*I express my deep thanks and heartfelt regards to Dr. A.H. Mughal, Associate Professor/Programme Coordinator, KVK, RARS, Kargil; Dr. A.H. Mir, Prof. & Head, Division of Agri-Statistics; Dr. Fayaz Ahmad Bandy, Prof. & Head, Division of Pomology and Dr. K.D. Farooqui, Professor Emeritus, SKUAST-K – the peerless members of my Advisory Committee for their constructive criticism, valuable advises and exorbitant help.*

*I express my sincere appreciation to the staff members at Directorate of Resident Instruction and Central Library staff for their help to accomplish this task.*

*I express heartiest appreciation for the valuable suggestions, constant help and cooperation received by me during the entire course of investigation from able tutors like Dr. K.N. Qaisar, Mr. P.A. Khan, Mr. A.H. Lone, Dr. A.A. Khan, Dr. M.K. Sharma, Mr. Nazir Ahmad, Mr. Zahoor Ahmad, Dr. Feza Ahmad, Mr. Javid Mughal, Dr. Parvez, Mr. Gh. Mohi-ud-din and others.*

*It is pertinent to mention here that my project would not have been accomplished successfully without the painstaking efforts and high level cooperation of Mr. Manzoor A. Rather, Mr. Gh. Mohi-ud-din, Mr. Manzoor Ahmad Bhat, Mr. Ishfaq Ahmad and other office/field staff of the Faculty of Forestry. I thank them for providing me timely help and facilities.*

*I extend special thanks to my dear friends – Mr. Dar Farooq, Mr. Mohd. Afzal and Mr. Mir Mushtaq for their constant support, help and encouragement.*

*I am highly thankful to my senior and friend Mr. Mumtaz Majeed who always stood by me and helped me whenever I needed.*

*I extend my thanks to my colleagues – Shamim ka, Arjumand, Altamash Bashir, Mushtaq Ahmad, Majid, Mudasar, Hilal, Suhail, Reyaz, Mubashir, Rouf, Basharat and others for their indispensable help throughout the course of investigation.*

*I am deeply indebted to my uncle and aunt Mr. and Mrs. Fayaz Ahmad for extending help to me whenever I needed it.*

*I shall be failing in my duties if I will not thank my family especially parents to whom I am deeply indebted for their tremendous moral and monetary support and constant encouragement.*

*Last but not least special thanks to Mr. Younus Ahmad and Mr. Rafiq Ahmad of M/s Universal Computers, Shalimar for composing this manuscript and giving it a final shape.*

*All those who care for me may not have got a mention, but none shall never be forgotten.*

*Arshad Ahmad Lala*

**Place : Shalimar, Srinagar**

**Dated :**

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## **CHAPTER – 1**

### **INTRODUCTION**

The evolution of man has been inextricably linked with the tangible and intangible benefits flowing from forests. However, our focus of attention has always remained on material benefits from this free natural resource. The phenomenal pressure of population, urbanization and industrialization has resulted in over exploitation of the natural forests, reducing the forest cover of India from about 40 per cent in 1952 to 21 per cent of its geographical area as against 33 per cent required under National Forest Policy. The present rate of 2.8 per cent deforestation is troublesome as compared to 0.07 per cent, per annum for the past centuries. The estimates indicate that during 1820-1990 about 60.3 per cent of forest were lost to agricultural activities, 27.0 per cent to town ships, 1.0 per cent to transmission lines and 3.72 per cent to miscellaneous usages (Kapoor, 1991; Anonymous, 2010).

The situation of forest resources in Jammu and Kashmir state is no different from the national scenario. Reports indicate that the forest area of the state is about 20230 sq km (8128 sq km in Kashmir, 12066 sq km in Jammu and 36 sq km in Ladakh) which accounts for about 19 per cent of geographical area of the state (Anonymous, 2010). The forest cover in hilly

areas under which Jammu and Kashmir falls should be 66 per cent as per National Forest Policy 1988. Thus, we can say that the forest area in the state is not adequate and is also shrinking rapidly as a result of various pressures exerted by increasing population (human and livestock), urbanization, extension of agriculture etc. So in order to reduce dependence on forests and at the same time fulfil the growing demand of population for forest products, there is a need to grow and exploit suitable fast growing tree species outside the conventional forest areas. Secondly, some of the indigenous tree species are endangered and are near extinction and therefore need attention from conservation point of view. Alder is one such species found in Kashmir which has been declared rare and endangered by Unjuman-e-Falah-I-Islam (UFI), a local Non-Governmental Organisation of Harwan, Srinagar. The tree has got multiple utility and can help in bridging the gap between demand and supply of fuel wood and small timber, therefore, needs to be grown outside forest areas on farm lands so that dual purpose of meeting needs of people and its extension and conservation is met.

Alder (*Alnus* spp.) commonly known as “CHAMP” in Kashmir valley, exhibit a wide diversity and occupy a wide variety of ecosystems throughout the northern hemisphere in the temperate as well as sub-tropical

regions of the world. Genus *Alnus* is distributed all over Europe, North America, The USSR, China, Japan, Thailand, South and North Korea, Nepal and Bhutan besides Indian sub-continent. Its diversity is so well pronounced that different species were evolved in different climates. There are as many as 35 species in the world (Mebberley, 1989), some of them are Gray Alder, *Alnus incana* (L.) Moench, European Alder *Alnus incana rugosa* (L.) Moench & (Du Roi) Clausen, Red Alder *Alnus rubra* Bong., Hazel Alder *Alnus serrulata* (Ait.) Willd., Green Alder *Alnus viridis* (Vill.) Lam. & DC., Sitka Alder *Alnus viridis sinuata* (Regel) A.&D. Love etc.

In India, *Alnus* is represented by two species viz., *A. nepalensis* and *A. nitida* Endl. (commonly known as Indian Alders). *A. nitida* (West Himalayan Alder) is confined to North Western Himalayas from the Yamuna westwards to Kashmir at altitudes between 900 and 2700 m (Troup, 1921). This Alder is always found in moist situations, mainly along the beds and banks of streams and rivers. It comes up gregariously on new land thrown up in the beds of rivers, where it forms pure crops, sometimes of considerable extent (Anon, 1976).

Alder tree is a major fuel wood species in its range and is generally encouraged in energy plantation (Vimal and Tyagi, 1984). Its heat content is comparable to Red Alder (*Alnus rubra*) 600 K cal/kg (Anonymous,

1980). It has good, even burning characteristic and has been used as firewood species since time immemorial. The species is extensively used in the manufacture of plywood, pencil slates, black boards, bobbins, packing cases and tea boxes etc (Anonymous, 1980). The bark contains 7 per cent tannins and is used in dyeing to deepen the colour of *Rubia* spp. (Anonymous, 1972). The young twigs are used for tying the loads, rope bridges and in the construction of baskets. It has also medicinal importance. It is very good astringent and a decoction of the bark is applied externally to treat swelling and body pains.

The wood is soft, even grained, hard to cut and is used for construction of furniture. Alders are described as commercial timbers (Pearson and Brown, 1932). The fresh leaves and cones are used as fodder occasionally (Laure, 1945). It is a pioneer species for afforestation of land slips and fresh earth cuttings in hill slopes and degraded habitats with low fertility levels (Luna, 1996). These are primary successional species forming *Alnus*, *Populus* community on newly formed sites on the river banks (Puri, 1960).

Under natural conditions *Alnus* propagates through seed, but its natural regeneration is negligible in the valley. Seed emptiness is a major cause of poor germination (Thapliyal and Rawat, 1991). Vegetative

propagation of forest tree species is potentially very useful for replicating clonal material for the multiplication of stock for plantation purposes, but so far no one has applied this method for its reproduction. Although some success has been reported elsewhere but it has not received any attention in the valley. Besides, no information is available with respect to its status and distribution in the Kashmir valley. Therefore, in order to collect some basic information with respect to its status, distribution, propagation etc. a project entitled **“Status and Propagation of Alder (*Alnus* spp.) tree in Kashmir valley”** was undertaken with the following main objectives :

- To study status and distribution of Alder tree in Kashmir valley
- To study propagation of Alder (*Alnus* sp.)

## **CHAPTER – 2**

### **REVIEW OF LITERATURE**

The discourse of the available literature shows that quite a good information is available with respect to Alders elsewhere and same has been reviewed under different aspects keeping in view the objectives of the study.

#### **2.1 Species identification**

Alder species can be identified on the basis phenological and morphological characters and has been described as a large tree, attaining a height of 80-100 ft and a girth of 6-12 ft, leaves 4-5 inches long, elliptical ovate, acuminate, entire or obscurely crenate. Bark is dark brown, rough with deep furrows (Troup, 1921).

The flowers are fully developed from August to October. Male catkins 4-10 inch long, about 4-6 together in terminal racemes. Female spikes about 0.3 inch long. Fruiting cones 0.7-1.5 inch long by 0.5 inch in diameter in erect lateral racemes. Nut with a narrow thickened edge. The fruits ripen in November-December. The empty cones remain long on the trees (Troup, 1921).

## 2.2 Distribution

Alder (*Alnus* spp.) exhibits a wide diversity and occupy a wide variety of ecosystems throughout the northern hemisphere in the temperate as well as subtropical regions of the world. Genus *Alnus* (Family : Betulaceae) is distributed all over Europe, North America, The USSR, China, Japan, Thailand, South and North Korea, Nepal and Bhutan besides Indian Sub-continent. About 35 species of genus *Alnus* are reported from different parts of the world (Mebberley, 1989). Some of them are Gray Alder, *Alnus incana* (L.) Moench, European Alder *Alnus incana rugosa* (L.) Moench & (Du Roi) Clausen, Red Alder *Alnus rubra* Bong., Hazel Alder *Alnus serrulata* (Ait.) Willd., Green Alder *Alnus viridis* (Vill.) Lam. & DC., Sitka Alder *Alnus viridis sinuata* (Regel) A.&D. Love etc. However, in India, *Alnus* is represented by only two species, these are *Alnus nepalensis* Don and *Alnus nitida* Endl., commonly known as Indian Alders (Troup, 1921).

Species found in India are distributed from eastern to western Himalayas.

- 1) ***Alnus nepalensis* Don (Nepalese Alder)** : Distributed throughout the Himalayas from the Ravi eastwards at 900-2700 m, sometimes lower, Khasi hills and the hills of upper Burma (Troup, 1921). From records

it is found that the species was first grown in Darjeeling forests in 1892 and in Kalingpong forests in 1919 (Ghosh and Ansari, 1971).

- 2) ***Alnus nitida* Endl (West Himalayan Alder)** : is confined to north western Himalayas from the Yamuna westwards to Kashmir at an altitude between 900 and 2700 m (Troup, 1921). This Alder is always found in moist situations, mainly along the beds and banks of streams and rivers. It comes up gregariously on new land thrown up in the beds of rivers, where it forms pure crops, sometimes of considerable extent (Anonymous, 1976).

## **2.3 Propagation studies**

### **2.3.1 Maturity indices**

In Alder, fruits/cones ripen in November-December (Troup, 1921). Seeds are available in December-January. Fruits/cones are collected by lopping and drying in the sun. The fruits/cones are beaten with a stick to extract the seeds (Luna, 1996). There are about 1.05 million seeds per kg. The percentage of purity is as low as 48 per cent. The initial moisture content of seeds is about 16.1 per cent and have limited viability upto 6 months (Thapliyal and Rawat, 1991).

The available literature scanned on Alder does not show any work on its maturity indices. Therefore, an attempt has been made hereunder to

review the literature with respect to seed and its maturity on other tree species.

The knowledge of exact stage and time of seed maturity is essential for collection of abundant quantity of healthy and vigorous seeds (Troup, 1921). Seeds collected when fully ripe retain viability longer than the seeds collected when immature (Harrington, 1970, Stein *et al.*, 1974). Immature seeds are low in viability and often produce low vigour and deformed seedlings (Suchbest, 1956; Heit, 1961). In Hoolong (*Dipterocarpus retusus*), seeds collected during first half of March showed maximum germination percentage (Thakur *et al.*, 2000). Similarly seeds of *Ulmus wallichiana* (Elm) collected on 3<sup>rd</sup> week of March showed highest germination percentage of 96 per cent (Bhat *et al.*, 2007a). Seeds of some species were capable of germinating a few days following anthesis (Gill, 1938, McAlister, 1943, Hume, 1984). Immature seeds die if they are allowed to dry out (Harrington, 1972). Thus fruit collection should be started only when the seeds are sufficiently mature. Therefore, indicators of maturity for individual species is a must, so that collection is made right in time. Otherwise immature collection of seeds will result in loss of time, money and failure of plantations.

The seeds of Alder are very weak and light and if allowed to ripe fully, these may get dispersed and may be carried away by wind. So the seeds need to be collected when they are sufficiently mature and cones are about to open. Change in colour of fruit provides a simple and in some species a reliable criteria for judging seed maturity (Willan, 1985). In Semal (*Bauhinia retusa*), the change in fruit colour from green to dark red and from green to whitish brown is a useful indicator of maturity (Upadhayay *et al.*, 2006). A relationship is often established between seed colour and maturity and thus is often used to determine physiological maturity of tree seeds as in *Platanus occidentalis* (Bonner, 1972) and *Quercus* spp. (Bonner, 1974). In such cases, fruit/seed colour changes are usually from green or white when immature to various shades of yellow, brown or grey when mature. The change in fruit colour has been shown to be the best available criteria for judging the maturation of seeds in *Ficus benjamina* and *Carissa opaca* (Mathani *et al.*, 1987).

Various workers have reported the maturity of coniferous trees based on specific gravity of cones, e.g. *Pinus elliottii*, *P. palustris* and *P. taeda* (Barnett, 1979), *Pinus strobus* (Bonner, 1976) and *Abies pindrow* (Singh, 1998). The specific gravity of mature cones in case of *Picea smithiana* (spruce) varied from 0.97 to 0.99 and moisture content from 20.97 to 22.12

per cent, respectively (Singh, 1989). The relationship between declining cone specific gravity and increasing seed germination has also been reported by a number of workers for different tree species (Cram and Worden, 1957; Fenton and Sucoff, 1965, Veracion and Padolina, 1971; Rietveld, 1978).

Singh and Kachari (2006) reported that the germination percentage of seeds increased with decrease in specific gravity and moisture content of cones of *Pinus kesiya* (Khasi pine). In *Celtis australis* (Hackberry tree) germination percentage increased from 0 to 23 per cent as the specific gravity decreased from 1.22 to 1.03 respectively (Singh, 2006). Effect of seed weight, nitrogen source and split application on the growth of *Celtis australis* was studied by Saleem *et al.* (1994) and reported that low seed weight gave the better germination whereas seedlings raised from heavy seed weight were healthy and having better growth. Bhat *et al.* (2007a) reported that seed weight increased from seed development stage upto its maturity and was maximum at its maturity. Variation in seed maturity often occurs among individual trees and even at different sides of a single tree. The slight difference in aspect, elevation and other climatic conditions affects the time of maturity of the cones. It even varies from cone to cone of the same tree (Ching, 1960) between trees of the same stand (Allen, 1958a),

between stands in the same year (Fowells, 1949) and also from one year to the next (Allen, 1958b). In such circumstances specific gravity proves as a useful guide for seed collection.

Seedlings raised from heavy seeds in case of *Quercus dilatata* (Moru oak) gave highest biomass, germination and growth (Tripathi and Khan, 1990). The acorns of *Quercus shumardii* and *Q. alba* showed a steady increase in dry weight till the final collection, however, the fresh weight of both the species after increasing throughout the season, levelled off in October (Bonner, 1974).

In *Altriplex cordobensis* (Aiazzi *et al.*, 1988) and *Fraxinus pennsylvanica* (Bonner, 1973), fruit, fresh weight declined in the final phase because of loss of moisture from seed. Maximum fresh weight does not indicate the physiological maturity because the maturing seed begins losing water while nutrients are still being accumulated and biochemical processes are continuing (Willan, 1985). The most generally accepted measure of maturity is the time when the seed has reached its maximum dry weight, a point called physiological maturity (Harrington, 1972).

### **2.3.2 Nursery raising from seeds**

Seeds of most species of *Alnus* characteristically show poor seed germination. Data from some species in the United States reveal seed

germination to vary from 4 to 59 per cent (Schopmeyer, 1974). Poor seed quality is frequently on account of large percentage of empty seeds. Normally seed do not exhibit any kind of dormancy and the germination capacity of sound seed is not affected by stratification (Thapliyal and Rawat, 1991).

In recent years interest to produce quality seedlings by application of improved modern techniques has increased. Obtaining vigorously growing healthy and uniform seedlings for raising quality plantation is the primary aim of nursery management. The traditional nursery practices have undergone a series of developments and introduction of root trainers in large scale, being the latest.

No information is available on raising of seedlings of Alder in root trainers and their comparison with those raised in seed beds. However, Maithani *et al.* (1990) studied standardization of nursery technique viz. method of seed sowing, optimum irrigation schedule of *Dalbergia sissoo* and concluded that line sowing method with twice a day irrigation (morning and evening) enhance germination of seeds, gives higher germination and survival. Bhat *et al.* (2007b) reported that the seeds of *U. wallichiana* (Elm) showed 91.66 per cent of germination in nursery beds, whereas the germination percentage was 85.33 per cent in the containers. Mughal

(1996) reported that *Cupressus torulosa* and *Cedrus deodara* attain optimum shoot and root development when grown in open nursery beds, while as seedlings grown in polybags do not exhibit better growth in terms of height and root development and also show deformities and confinement in immediate vicinity.

Qaisar and Mishra (2005) studied the nursery performance of *Acacia catechu* seedlings raised in different type and size of containers. The bottom perforated polybag and root trainer raised seedlings depicted better values of seedling quality parameters viz. sturdiness, root/shoot ratio, ratio of fibrous to total root biomass and Dickson quality index, which indicated the overall quality of seedlings.

Misra and Jaiswal (1993) reported maximum survival, collar diameter, plant height, in the bigger size of polybags used. Venkatesh *et al.* (2002) reported that the size of the container has profound influence on *Acacia nilotica* subspp. Indica seedlings morphometric parameters. The container of 15 x 20 cm size registered superiority over 10 x 15 cm size polythene containers and the seedlings grown in the nursery beds, for the growth characteristics of seedling length, shoot collar diameter and total dry weight.

The seedlings grown in polythene bags can easily be transported and planted without any damage. The requirement of the size of the polythene bags differ from one plant species to other (Misra and Jaiswal, 1993).

Sutherland and Day (1988) reported increase in seedling growth from 72 to 360 per cent where the container volume was tripled in size. The seedlings of *Acacia nilotica*, *Albizia procera* and *Dalbergia sissoo* attained higher values of shoot length and collar diameter in polythene bag raised seedlings (Gera *et al.*, 2001).

### **2.3.3 Vegetative propagation**

The technique of vegetative propagation assumes great significance as it is potentially very useful for multiplication of stock for plantation purposes, introduction of fast growing species and genetic improvement of forest tree species. Infact the method is emerging as a strong alternative to seed propagation and is being employed for operational planting, increasing productivity in many forest plantations all over the world. Vegetative propagation is most convenient, easiest and economical method of raising superior stock for some important crops (Hartman *et al.*, 1993). The vegetatively propagated plants have got the advantage of exhibiting faster growth rate (Ooyamma and Toyoshima, 1965) greater stock stand uniformity, better site matching and true to type production (Fielding,

1969). Planting by shoot cuttings is mostly adopted as it is very convenient and good results are expected.

The cuttings vary considerably in their rooting response. Cuttings can be categorised broadly into three main groups viz., easy to root, difficult to root and obstinate to root (Nanda, 1970). Poplars and willows root easily even without use of growth regulators (Guha, 1973). Pines are considered to be obstinate to root by many workers (Deuber, 1942, Allsop, 1950).

Phytohormones and other chemicals have been tried by several researchers but only auxins have been found to promote the adventitious root formation in cuttings most consistently (Nanda, 1975; Pal, 1988; Hartmann *et al.*, 1997; Husen and Mishra, 2001; Husen, 2002) and were frequently used for clonal propagation.

Thakur and Gupta (1998) studied the effect of auxins on rooting of *Alnus nitida*, Endl. cuttings. Cuttings from 6 years old trees of *Alnus nitida* were treated with IAA, IBA, NAA (200, 400, 600, 800 and 1000 ppm) for 24 hours. Callus formation and rooting were observed over 6 months. Rooting was better in all treatments except for 800 ppm and 1000 ppm IAA. Maximum rooting was with the 800 ppm IBA treatment.

Thakur (1999) studied effect of season and auxin concentration on rooting and sprouting of *Alnus nitida*, Endl. stem cuttings. Cuttings from a 4 year old plantation in H.P were given three auxin treatments using IAA, IBA or NAA at 3 concentration (50, 100 or 200 ppm) in February, July, September, and November. Cuttings collected in November gave little or no rooting with or without auxin treatment, while September cuttings showed some response. The cuttings planted in February and July responded well to various auxin treatments, particularly 100 and 200 ppm IBA and 100 ppm NAA. Maximum percentage rooting was observed in February cuttings treated with 200 ppm IBA while highest number of sprouts and number of roots per cuttings were found with the same treatment in July and February cuttings respectively. Maximum root length per cutting was noted in the February cuttings treated with 100 ppm NAA.

Thakur and Pant (2002) studied vegetative propagation of *Alnus nitida*. The treatments included control (water treatment) and 400, 800, 1200 and 1600 ppm of IAA, IBA and NAA respectively. The results showed that rooting occurred in all the treatments including control. The highest rooting percentage was noted in 1200 ppm IBA treated cuttings. Maximum sprouting percentage and highest average root ratio was observed in 800 ppm IBA. Maximum root shoot ratio was observed in 800

ppm IAA and 1600 ppm IBA treatments. Maximum shoots height was found in 1600 ppm IBA treatment.

Rinallo (1977) reported that cuttings of *A. cordata* taken monthly throughout the year showed substantial variation in rooting. The rooting success in control treatment was best in January, March and June, while cuttings treated with auxins rooted best in March, June and December. Variability in rooting behaviour is explained in terms of the phenological phases of the tree. During October - December, low temperature seemed to have a positive effect on rooting.

Monaco *et al.* (1980) used the basal ends of cuttings from 2 year old seedlings which were treated with a solution of IBA (concentration 4,000-10,000 ppm) or solvent (2% ethanol) and/or dusted with 10 per cent benomyl and examined after 6 weeks. The highest proportion of cuttings rooted when treated with 4,000 or 8,000 ppm IBA and benomyl and kept at 25, 22°C (day/night temperatures). Treatments with 8,000 ppm of IBA produced more roots per cutting and better branched roots at 4,000 ppm.

Danell *et al.* (1980) tried rooting of leafy cuttings of *Alnus incana* and reported the highest percentage of rooting (94%) in green house condition (20-25 °C; 90 RH; coarse sand medium). Early May was recommended to be the best time for taking cuttings.

Saul and Zsuffa (1982) reported that lignified cuttings from trees (20-25 years old) and green cuttings from 2 years old seedlings rooted readily in several mixtures in green house. The best medium was perlite/sand (1: 1) mixture.

Psota *et al.* (1986) studied the response of auxins on rooting of *Alnus glutinosa* stem cuttings and reported that response to treatment with 'auxin was the greatest during dormancy. At that time control cuttings showed only 5 to 63 per cent rooting, whereas, the treated cuttings showed almost 100 per cent rooting. A positive response to IAA was also observed after dormancy.

Although good amount of work has been conducted elsewhere on Alder, but no information is available on this tree with respect to Kashmir conditions where it has been declared as endangered. Therefore a project proposal entitled "Status and Propagation of Alder (*Alnus* spp.) tree in Kashmir valley" has been undertaken.

## CHAPTER – 3

### MATERIAL AND METHODS

The investigations to accomplish the project “Status and propagation of Alder (*Alnus* spp.) in Kashmir Valley” were carried out in the Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar during the years 2007 to 2009. The details of techniques followed and materials used during the course of investigation are described below keeping in view the objectives of the project.

#### 3.1 Experimental site : location, physiography and climate

The valley of Kashmir, the experimental site for survey, is a unique oval plain, surrounded by chain of mountainous ring and rested securely among the Pir Panjal range of Himalayas. The valley is divided into 10 districts.

Nursery of Faculty of Forestry, Shalimar, the experimental site for nursery practices is located between 74.89° E longitude and 34.08° N latitude at an altitude of about 1587 m above mean sea level. It is roughly 15 km north of the Srinagar city. The nursery is well-drained having silty loam soil.

The climate in general is temperate; with severe winter extending from December to March. The region faces a wide temperature range from a minimum of -8.0 °C in winter to a maximum of 33 °C in the summers. Winter frost is common and medium to heavy snowfall is also witnessed. The area receives an annual precipitation of 676-1193 mm, with an average of 944.6 mm.

### **3.2 Status distribution and concentration of Alder in Kashmir Valley**

This objective was achieved by conducting detailed survey at village level of all the districts of Kashmir Valley and observations with regard to the existing Alder species on the basis of phenological studies along with their status, distribution and concentration were recorded.

For collection of relevant data regarding status and distribution, four blocks from each district were selected randomly. Subsequently from each block, four Panchayats were selected and data was collected from two villages from each Panchayat. Thus, information was collected from about 320 sites all over the valley. The approximate number of trees existing at a given site was also recorded. The information was collected as per the Annexure-I which has been developed by the Faculty of Forestry, for the purpose.

Following methods were employed to collect the data from surveyed areas:

### **3.2.1 Informal interview method**

Collection of information was done during informal interviews with the farmers, elder and respectable citizens of the concerned areas. Generally, open-ended questions were asked for getting the information.

### **3.2.2 Transit walk method**

Information was also collected during the transit walk of the villages. Transit walk gave more scope to discuss with farmers freely in their farmlands while walking through their farms in friendly mode.

### **3.3 Identification of species**

In the first instance, efforts were made to identify various species of Betulaceae family as well as different varieties of Alder (*Alnus nitida* Endl.) in Kashmir valley. For this purpose a detailed survey was conducted at village level in all the districts of the Valley. Survey was conducted in two important seasons i.e. autumn, when leaves and mature fruits are present on trees and spring during the flowering season. In order to identify the tree help was taken from taxonomists as well as people who were shown samples of leaves as well as seeds at various stages of maturity to know whether they have seen the trees with such leaves and seeds or its look likes.

An attempt to find its vernacular name (Kashmiri name) was also made.

### **3.3.1 Identification of oldest living Alder trees**

Information was also collected with, respect to oldest living Alder trees in the Kashmir Valley. The oldest living Alder trees were identified and information with respect to their location, approximate age, height, girth at breast height was recorded. The approximate age was determined by interviewing the senior residents of the locality. The height of the tree was determined with the help of clinometer and girth was measured by measuring tape. Photographs of all the identified trees were also taken.

### **3.4 Propagation studies on Alder**

The studies were undertaken to determine :

- ➔ Maturity indices
- ➔ Raising of seedling nursery
- ➔ Vegetative propagation through pre-conditioned and treated cuttings

#### **3.4.1 Maturity indices**

The optimal time to harvest is when a large amount of viable germinable seeds can be collected. In order to determine the best time for

collection of seeds, the cones/fruits were collected from identified phenotypically superior trees located in New Theed, Harwan, Srinagar. The cones/fruits were picked from October till their maturation at an interval of 15 days and information about specific gravity, fruit weight, change in fruit colour, seed dimensions, seed weight and germination percentage was recorded.

#### **3.4.1.1 Cone colour**

Colour change in fruit/seed provides a simple and reliable criteria for judging seed maturity (Willan, 1985). Therefore to relate fruit/seed colour change with maturity of seed, the fruits were picked with effect from October. Observations were taken with regard to change in fruit/seed colour to different shades till their maturation.

#### **3.4.1.2 Specific gravity**

The specific gravity of cones was determined by water displacement method as described by Barnett (1979). The specific gravity of cones was determined by dividing the weight of cones by the volume of water displaced by the same (Oliver, 1974).

$$\text{Specific gravity} = \frac{\text{Cone/fruit weight}}{\text{Volume of water displaced by cones/fruits}}$$

On each collection date, some cones of known total weight were placed in known volume of water in a volumetric cylinder and the volume of water displaced was recorded. The specific gravity of cones was calculated by the above captioned formula. To alleviate the error several replication were used and average was taken. The cones were collected from 1<sup>st</sup> October at an interval of 15 days till maturation.

#### **3.4.1.3 Cone weight**

Average cone/fruit weight was recorded by using sensitive top pan balance. The cones/fruits were picked with effect from October till their maturation at an interval of 15 days.

#### **3.4.1.4 Seed weight**

Seed weight of 800 bold and filled seeds was recorded, using 8 replications of 100 seeds each with the help of sensitive top pan balance and finally transformed into 1000-seed weight by multiplying 100-seed weight by a factor of 10 (ISTA, 1993). The seeds were picked with effect from October till their maturation at an interval of 15 days.

#### **3.4.1.5 Germination of seed**

The germination test was performed in petri-plates lined with double fold germination paper at bottom. The 100-seeds in four replicates were

placed sparsely in petriplates and moistened. The plates were incubated at  $25\pm 1$  °C in a B.O.D. incubator for a period of 28 days. The plates were kept moist and inspected regularly. Seeds were considered to have germinated as soon as radical emerged. Germination was recorded daily after second day of seed placement.

The germination percentage was calculated as per following standard method :

$$\text{i) Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds}} \times 100$$

### **3.4.2 Raising of seedling nursery**

The seedling nursery of Alder was raised from bold and filled seeds in nursery beds as well as in root trainers at Forest Nursery, Faculty of Forestry, SKUAST-K, Shalimar. Open beds of size 1 m x 1 m were prepared and mixed with sand and FYM. Seeds were sown in beds in the first week of March, 2008. 400 seeds pre-soaked for 24 hours were sown per bed at a spacing of 5 x 5 cm. Beds were well prepared before sowing. Beds were irrigated as and when required.

The sowing in root trainers was also carried out at the same time. The root trainers were also filled with soil, sand and FYM (2:1:1). Root

trainers of 150 cc capacity with 24 plugs in each tray were used for the purpose.

The performance of both open bed seedling nursery as well as root trainer seedling nursery was studied in terms of germination percentage, survival percentage, shoot height (cm), collar diameter (mm), root length (cm) and root-shoot ratio. The studies were conducted for one growing season and monitored periodically.

### **3.4.3 Vegetative propagation of Alder through treated stem cuttings**

#### **3.4.3.1 Through treated hardwood cuttings**

Alder is commonly propagated through seed, however, vegetative propagation in general and growth hormone treated cuttings in particular has become an indispensable tool in mass propagation of desired genotypes. Treating cuttings with auxins or other plant growth regulators (PGRs) are believed to promote root initiation and also help in root cell multiplication and elongation. Therefore, in order to determine the effect of different plant growth regulators on root initiation of Alder cuttings, hardwood and softwood cuttings having pencil thickness (1.5-2 cm) were used. The cuttings collected from phenotypically superior and young mother trees from Ramban area in spring (The propagating material from Harwan area was unable to show results in the previous trail probably due to loss of

rejuvenation power as the trees were very old) were treated with following plant growth regulators (PGR) at given concentrations in 4 replications :

<b>S. No.</b>	<b>Name of PGR</b>	<b>Concentrations used (ppm)</b>
1.	Indole-3-Acetic Acid (IAA)	400, 700, 1000, 13000
2.	Indole-3-Butyric acid (IBA)	400, 700, 1000, 13000
3.	Naphthalene-Acetic acid (NAA)	400, 700, 1000, 13000
4.	Combinations of IBA and NAA	400, 700, 1000, 13000

The propagation through cuttings was carried out at Forest Nursery, Faculty of Forestry, SKUAST-K, Shalimar. Hardwood cuttings were first pre-conditioned and then treated with growth hormones for 24 hours and planted immediately in well prepared nursery beds at a spacing of 25 x 25 cm. The plot size was kept equal to 1.12 x 1.12 m accommodating 20 cuttings. The beds were irrigated and kept weed free. Cuttings were also planted in polybags of 5" x 7" size. The observations were taken with regard to sprouting percentage, rooting percentage, survival percentage, shoot height (cm) and collar diameter (mm) of leading shoot, root length (cm) and root diameter (mm). Cuttings were treated with simple distilled water for maintaining control.

#### **3.4.3.2 Through treated softwood cuttings**

The softwood cuttings of Alder were taken in July and were treated with same treatments as that of hardwood cuttings. However, they were given quick dip for a period of 30 seconds and planted immediately in polybags. Due care was taken with respect to watering and weeding. The observations were taken with regard to rooting/survival, shoot height, diameter of leading shoot, root length and root diameter. Cuttings were treated with simple distilled water for maintaining control.

#### **3.5 Statistical analysis**

The data thus obtained was subjected to the appropriate statistical analysis as per procedure given by Gomez and Gomez (1984).

## CHAPTER – 4

### EXPERIMENTAL FINDINGS

The experimental findings of the studies conducted on “Status and propagation of Alder tree (*Alnus* spp.) in Kashmir valley” as per the methodology adopted in previous chapter has been presented hereunder and tabled from 1 to 11 alongwith Fig. 1 to 4 and Plate 1 to 21.

#### **4.1 Status and distribution of Alder tree (*Alnus* spp.) in Kashmir valley**

##### **4.1.1 Specie identification**

Detailed survey conducted revealed that only one *Alnus* species was found growing in the valley and was identified as *Alnus nitida* Endl. on the basis of its phenotypical and phenological characteristics, which have been presented in Table-1, 2 and described as follows.

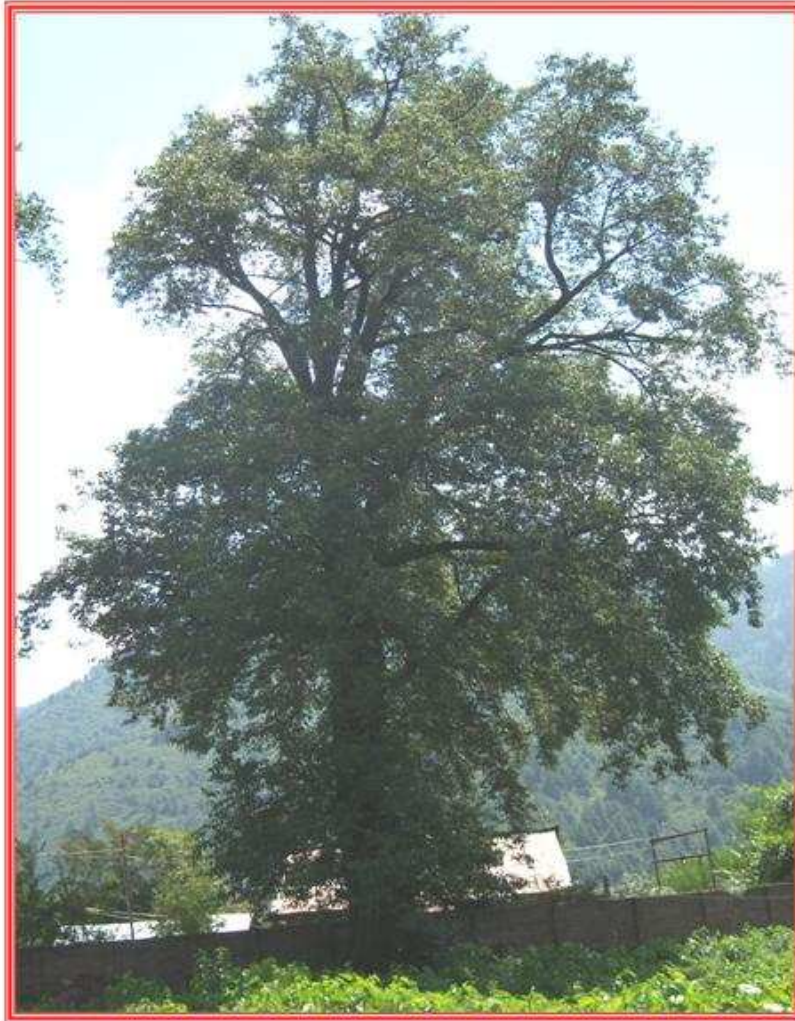
It is a large semi-deciduous tree with a straight trunk (Plate-1) and spherical but spreading crown (Plate-2 & 3) of dark green foliage. Its average height recorded was about 35 m and average DBH of about 180 cm. The stem bark was grey with longitudinal furrows (Plate-5) but in the pole stage the bark was reddish brown, thin and smooth often with yellowish patches and short, raised lenticels (Plate-4). The leaves

**Table-1 : Phenotypal characteristics of West Himalayan Alder (*Alnus nitida* Endl.) trees observed in Kashmir valley**

Phenotypic characteristics	Observations
Tree form	Spherical with spreading crown
Average tree height	35 m
Average tree dbh	180 cm
Bark	Deep brown rough with deep furrows
Leaves	10-12.5 cm long, elliptical ovate, acuminate entire or obscurely crenate
Phyllotaxy	Alternate
Flower	Male green (immature); yellow (mature), 4-6 inch long, 4-6 together in terminal racemes
	Female green (immature); brown (mature), 0.3 inch long
Fruit	Cone with thickened edge, 0.7-1.5 inch long by 0.5 inch in diameter in erect lateral racemes
Average number of seeds/cone	200
Seed colour	Creamy white (immature), Chocolate brown (mature)
Seed weight (kg)	0.32 to 0.42 million/kg

**Table-2 : Phenological characteristics of West Himalayan Alder (*Alnus nitida* Endl.) trees observed in Kashmir valley**

<b>Phenological characteristics</b>	<b>Observations</b>
Habit	Semi-deciduous
Reproductive habit	Monoecious with uni-sexual flowers
Leaf renewal	March
Leaf shedding	December-January
Flowering	July-August
Pollination	August-September
Pollinators	Wind/honeybee
Seed set	October
Seed maturity/dispersal	Last week of December
Seed dispersal agents	Wind
Seed longevity	3-4 months
Percentage purity	48



**Plate-1 : West Himalayan Alder tree (*Alnus nitida* Endl.)**

10-12.5 cm long, 5-8 cm wide were alternate, elliptical and acuminate and crenate (Plate-7 & 8). The upper leaf surface was dark green but the lower surface was pale green. The branching was alternate (Plate-6). Leaves were shed from December-January and new flush of leaves developed in the month of February-March so deciduous period was for a very short period and thus the tree can be described as semi-deciduous. The tree flowered in July-August and was found Monoecious with unisexual flowers. Narrowly cylindrical clusters of male catkins 4-6 inch long and green in colour appeared at the end of twigs in terminal racemes (Plate-9) by July-August and turned yellow by August-September. After pollen dispersal the colour of male catkins turned brown and fell down. Female catkins (Plate-10) much shorter, erect and woody occurred on branching side twigs also in terminal racemes separately on the same or different twigs at the same time but achieved full development only after pollination in August-September. The tree is wind pollinated and pollination takes place in August-September. The fruits (Plate-11) which superficially resembled cones of the pine family were dark brown, elliptical, composed of many spreading hardwoody scales. Seeds got set in October and matured in the last week of December. Seeds (Plate-12 & 13) were shiny chocolate brown, circulate and flat with two broad membranous wings more than 2 mm across. Empty cones persisted on the trees for a very long time.



Plate-2 : West Himalayan Alder tree (*Alnus nitida* Endl.) crown (young) : spherical in form



Plate-3 : West Himalayan Alder tree (*Alnus nitida* Endl.) crown (old) : spherical but spreading in form



Plate-4 : West Himalayan Alder tree (*Alnus nitida* Endl.) bark (young) : smooth, reddish with yellow lenticles



Plate-5 : West Himalayan Alder tree (*Alnus nitida* Endl.) bark (old) : brown rough with deep furrows



Plate-6 : West Himalayan Alder tree (*Alnus nitida* Endl.) branching : Alternate



Plate-7 : West Himalayan Alder tree (*Alnus nitida* Endl.) twig : showing alternate leaf arrangement

The phenotypical and phenological observations thus recorded revealed that the *Alnus* spp. growing in the valley was similar to that of West Himalayan Alder (*Alnus nitida* Endl.) as described and reported earlier by Troup (1921). Therefore, all the studies conducted and reported here after pertain to West Himalayan Alder (*Alnus nitida* Endl.). Although the tree is known by various other names but West Himalayan Alder is used in present study as the same name is most common world over. So for the local names are concerned it is called as ‘Champ’, in Kashmir valley, ‘Zamp’ in Ramban area and ‘Sarol’ in in Kishtwar and Poonch region.

After surveying about 320 sites all over the valley selected randomly from all the 10 districts (Appendix-I), it was found that the tree growing here do not show any variation and show similar morphological characteristics as that of West Himalayan Alder.

#### **4.1.2 Status and distribution**

The objective was achieved by conducting an extensive survey at village level of all the districts of Kashmir valley and observations were taken from about 320 sites with regard to its status, distribution and concentration. Observations were also taken with respect to old existing West Himalayan Alder trees. The detailed survey conducted at all the sites revealed non-existence of the tree species in Kashmir valley except

Harwan and Sonawar. In Harwan only 3 trees were found growing whereas some plants of 5 to 6 years age were located in a Forest Department Nursery at Sonawar. However, the tree was found growing abundantly in other parts of J&K viz. Ramban, Batote, Chenani, Kishtwar, Udhampur, Poonch, Rajouri etc. which falls under temperate monsoon belt and fall outside the jurisdiction of the study.

#### **Oldest Alder trees of Kashmir valley**

<b>S. No.</b>	<b>Location</b>	<b>Height (m)</b>	<b>DBH (cm)</b>	<b>Age (years)</b>
1.	Sericulture Department, Theed, Harwan, Srinagar	34	210	150
2.	-do-	36	190	150
3.	Private Orchard at Theed, Harwan, Srinagar	35	140	80

The trees found in Harwan, Srinagar were oldest ones (Plates- 14). Two of these were growing in the Sericulture Department with approximate height of about 35 m and approximate DBH equal to 190 and 210 cm, respectively and another one was found growing in a private orchard in the same area which is about 80 years old with height and DBH equal to 35 m and 140 cm, respectively. Both these locations are having a nallah passing nearby which proves its pioneering nature as the tree is characteristically found in moist situations, mostly along the beds and banks of streams and

rivers. The tree has been declared rare and endangered by Unjuman-e-Falahi-i-Islam (UFI), a local non-governmental organisation of Harwan, Srinagar and are being protected by the same organisation.

While making an attempt to know about the origin of these trees, it was known that two schools of thoughts prevailed there. According to one school of thought there existed a large number of trees in the past but due to excessive felling of trees for their use as fuel wood, their number have reduced to just three at present. However, as per another school of thought there existed a Forest Department in the past at this location and the English Forest Officers got Alder seeds from outside and sowed them there. According to Dr. G.A. Bhat, Professor Centre of Research for Development/PG Department of Environmental Science, University of Kashmir, Srinagar, there are the only three *Alnus* trees growing in the Kashmir valley. According to Dr. M.S. Wadoo, Retired DCF and author of many books on forest trees of Kashmir, the tree is always found in the monsoon areas and thus in J&K it is found in areas like Rajouri, Kishtwar, Udhampur, Poonch, etc. and in Kashmir there are chances that it may be found in Uri Tehsil of Baramulla but on survey of the Baramulla district no Alder tree was found.

Same view was exhibited by most of the forest officials of the J&K

Forest Department. However, an attempt has been made by Mr. Arshad, a Forester while working in forest nursery, Sonwar, Srinagar to raise it artificially from seed and thus in the same nursery I found about 5-6 vigorously growing Alder plants which are about 3-4 years old.

## **4.2 Propagation of West Himalayan Alder**

The studies were undertaken to determine :

- Maturity indices
- Nursery raising
- Vegetative propagation of Alder tree through treated hardwood and softwood stem cuttings

### **4.2.1 Maturity indices**

The maturity indices studies were conducted on the only available trees at Harwan, Srinagar and presented in Table-3. The observations taken with respect to maturity indices revealed that West Himalayan Alder (*Alnus nitida* Endl.) comes into flowering in the month of July-August and are fully developed upto October. The flowers are monoecious (individual flowers are either male or female but both sexes are found on the same plant). They are mainly pollinated by wind but are also visited by bees to a small extent. The flowers are catkins with elongated male and shorter female catkins. Male catkins are 4-6 inches long, and about 4-6 together in

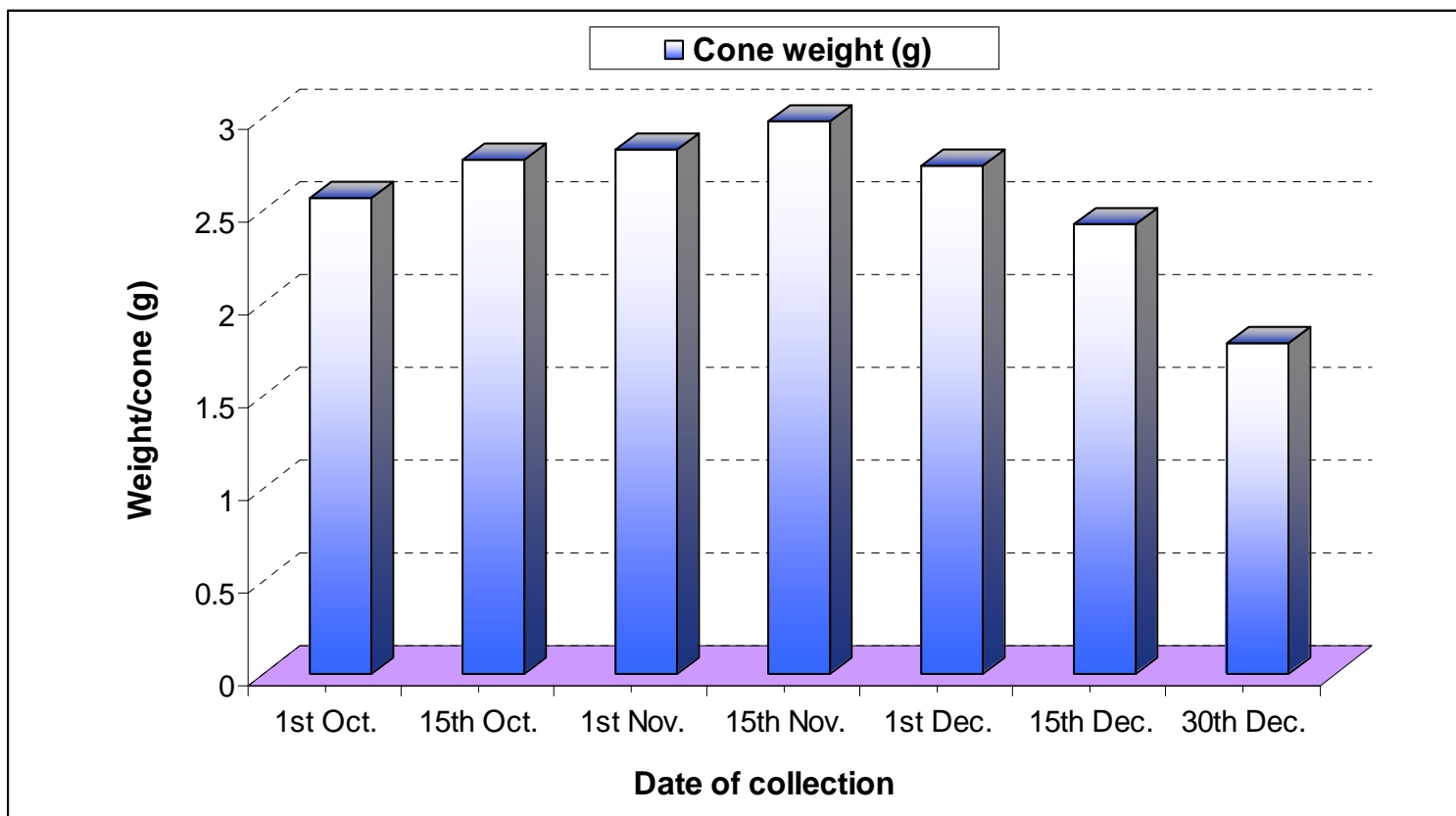
terminal racemes (Plate-9). Female spikes about 0.3 inch long also occur in terminal racemes (Plate-10). The female catkins turn woody and cone like at maturity. Fruiting cones 0.7-1.5 inches long by 0.50 inches in diameter in erect lateral racemes are dark brown, elliptical and composed of many spreading hardwood scales (Plate-11). Fruits ripen in November-December. Seeds are light brown, circular and flat with two broad membranous wings more than 2 mm across (Plate-12 & 13). The empty cones remain long on the trees.

The optimal time to harvest fruit/seed is when a large amount of germinable seeds can be collected. In order to determine the optimal time for seed collection of West Himalayan Alder (*Alnus nitida* Endl.), the fruits were collected from the available Alder trees in Harwan after every 15 days of interval with effect from October till maturation. The data collected and presented in the Table-3 showed that fruit colour, fruit weight, seed coat colour and specific gravity had a significant effect on the germination percentage of *Alnus* seeds vis-à-vis maturation of Alder seeds.

Initially at the first collection date the cone weight was about 2.57 g. It showed an increase upto 15<sup>th</sup> of November when it was 2.98 g. Afterwards it started to decrease and on 30<sup>th</sup> December it was about 1.78 g (Fig. 1; Table-3).

**Table-3 : Effect of collection dates on the maturity indices of West Himalayan Alder (*Alnus nitida* Endl.)**

Date of collection	Cone colour	Cone weight (g)	Specific gravity	1000-seed weight (g)	Germination (%)
1 <sup>st</sup> October	Green	2.57	0.99	0.00	0.00
15 <sup>th</sup> October	Green	2.78	0.96	2.01	0.00
1 <sup>st</sup> November	Light green	2.83	0.856	2.10	13.50
15 <sup>th</sup> November	Green with very large small brown patches	2.98	0.793	2.50	31.25
1 <sup>st</sup> December	Green with large brown patches	2.74	0.771	2.83	35.50
15 <sup>th</sup> December	Brown with green patches	2.43	0.727	3.20	42.00
30 <sup>th</sup> December	Brown	1.78	0.656	3.10	41.75

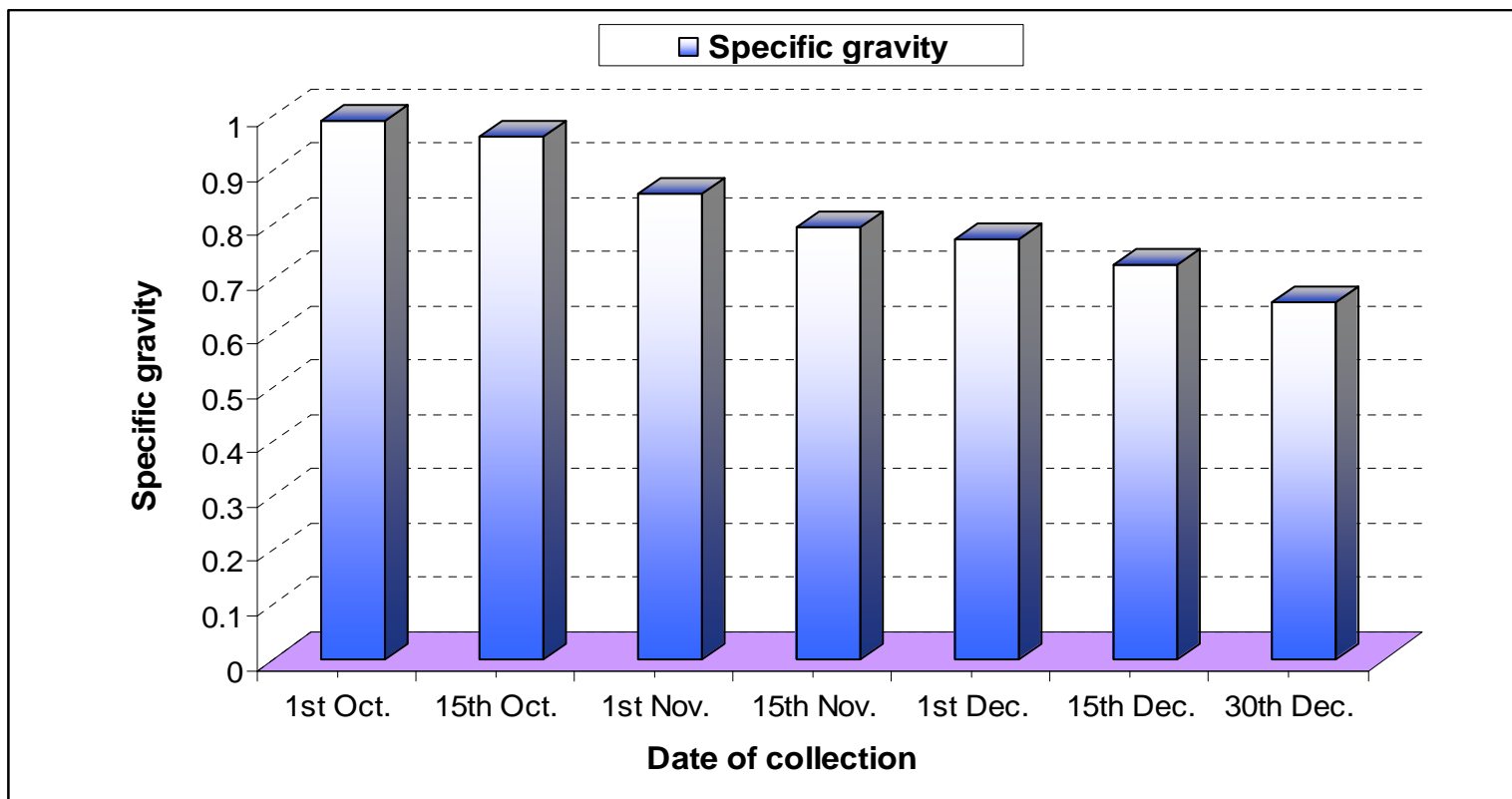


**Fig. 1 :** Effect of collection dates on cone weight of West Himalayan Alder (*Alnus nitida* Endl.)

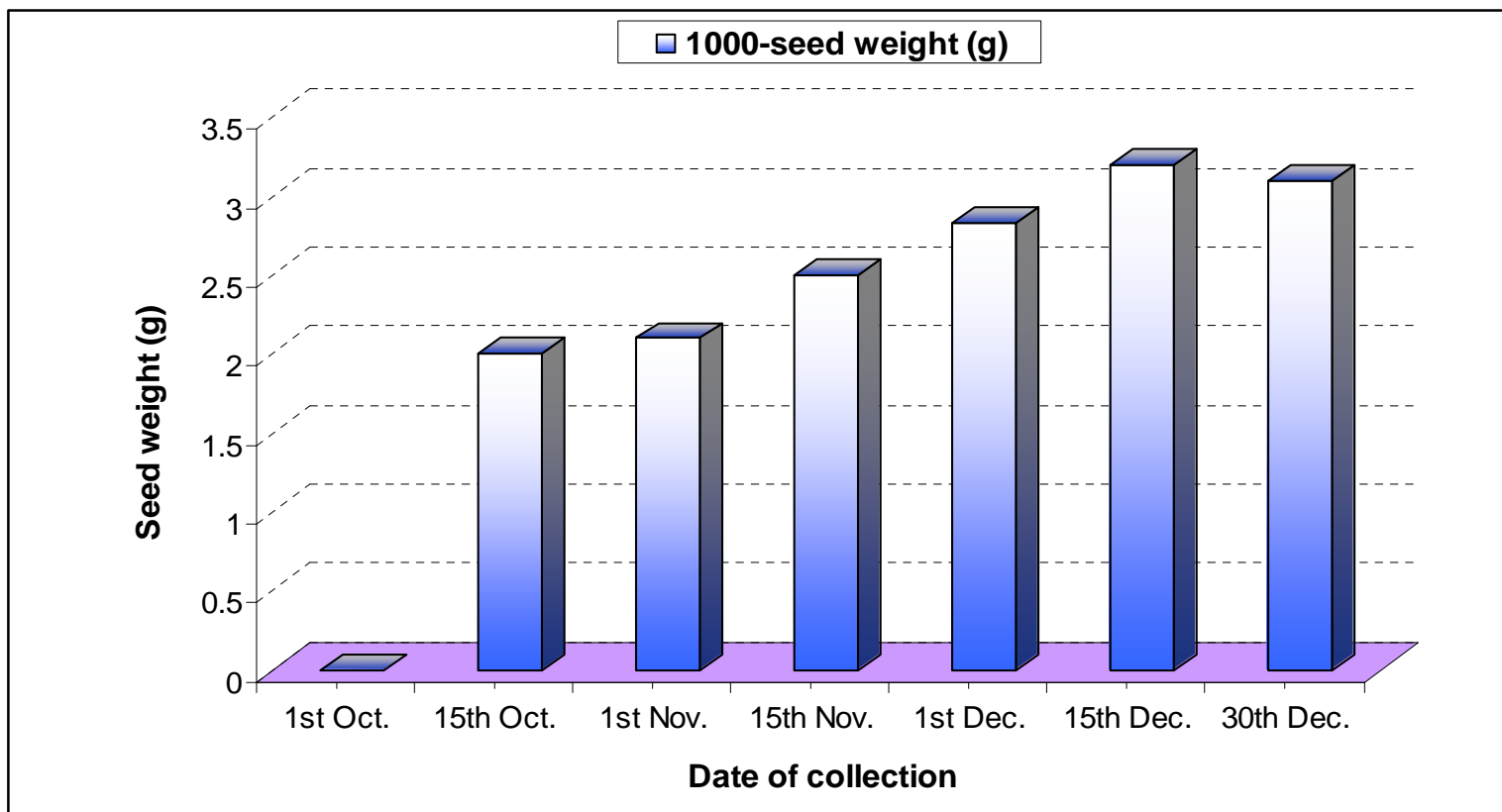
The specific gravity of the West Himalayan Alder cones at different collection dates, also differed from date to date (Table-3 and Fig. 2). It decreased from 0.99 (immature) to 0.656 with maturity of fruit/seed. No germination (0%) was recorded when specific gravity of cone was 0.99 and 0.96 (maximum) and fruits were green (immature) and also when seeds were white and papery. However, the maximum germination percentage of 42.0 was recorded when specific gravity of cones was equal to 0.727 and the colour of seed and cone had turned brown. Thus germination percentage and specific gravity had a negative correlation with each other.

The studies further revealed that as soon as seed coat colour changed from creamy white to creamy white with brown patches, seeds started to germinate and germination per cent increased reasonably in relation to colour change from creamy white with brown patches to shiny chocolate brown (Plates-11 & 12). The maximum germination percentage of 42.0 was found when seed coat colour was shiny chocolate brown.

Seed weight of 1000 filled seeds collected on first of October, was found to be 2.01 g (Table-3) whereas seed weight of 1000-seeds collected on its maturity i.e. 30<sup>th</sup> December as determined was found to be 3.1 g. This showed that seed weight increased during development and was maximum at its maturity (Fig. 3). No germination was observed when seed weight was



**Fig. 2 :** Effect of collection dates on specific gravity of West Himalayan Alder (*Alnus nitida* Endl.) cones



**Fig. 3 :** Effect of collection dates on seed weight of West Himalayan Alder (*Alnus nitida* Endl.)



Plate-8 : West Himalayan Alder tree (*Alnus nitida* Endl.) leaf : ovate and acuminate



Plate-9 : West Himalayan Alder tree (*Alnus nitida* Endl.) male inflorescence : raceme



Plate-10 : West Himalayan Alder tree (*Alnus nitida* Endl.) female inflorescence : raceme



Plate-11 : Fruit set of West Himalayan Alder tree (*Alnus nitida* Endl.)

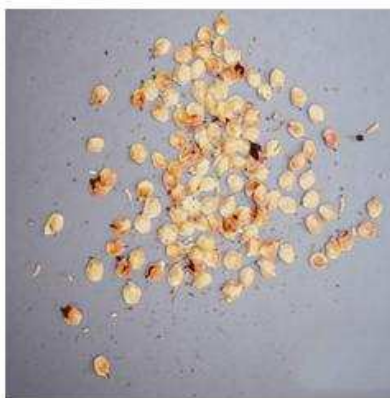


Plate-12 : West Himalayan Alder tree (*Alnus nitida* Endl.) seed at early stage



Plate-13 : West Himalayan Alder tree (*Alnus nitida* Endl.) seed at maturity

below 2.10 g. The germination percentage ranging from 13.5 to 42.0 was observed when the seed weight was recorded between 1<sup>st</sup> November to 15<sup>th</sup> December. However, the maximum of 42.0 per cent germination was recorded when the seed weight was 3.2 g (15<sup>th</sup> December) [Table-3; Fig. 4 and Plate-15].

The studies conducted on maturity indices therefore, revealed that the proper stage for harvesting of West Himalayan Alder fruits was when fruit/seed colour is brown and specific gravity is equal to 0.727. The maximum of 42.0 per cent germination was recorded on 15.12.2008 and therefore second fortnight of December is the best time for collection of Alder seeds.

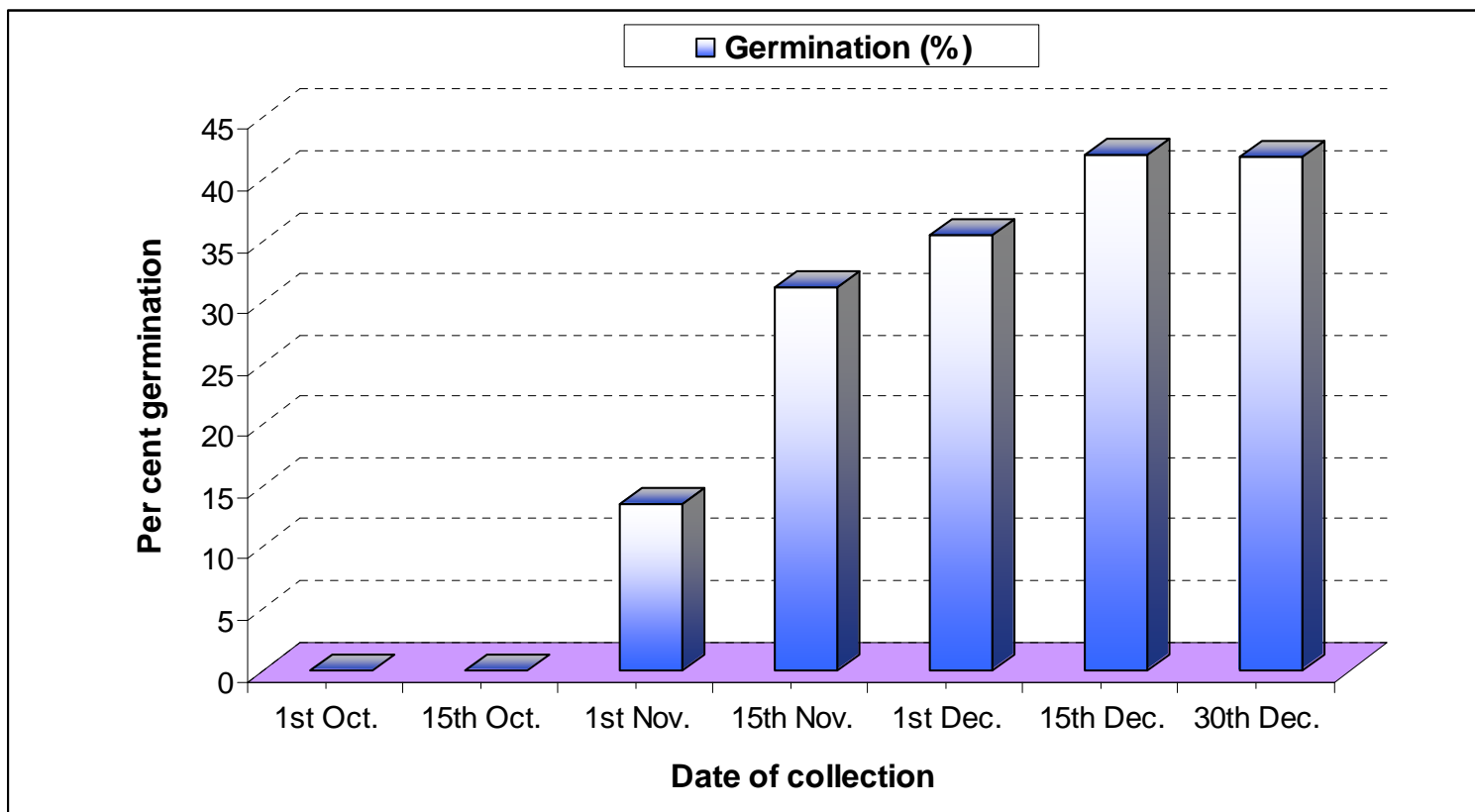
#### **4.2.2 Raising of seedling nursery**

The seedling nursery of West Himalayan Alder (*Alnus nitida* Endl.) was raised in open nursery beds as well as in root trainers (150 cc) [Table-4, Plate-16 & 17]. The performance of seedling nursery in both cases was assessed in terms of germination percentage, survival percentage, shoot height, root length, collar diameter and root shoot ratio. The observations recorded are presented in Table-4. The analysis of data revealed that there was no significant difference in germination and survival percentage between open beds and root trainer raised seedlings. The germination

**Table-4 : Comparison between containerised (root trainer) and non-containerised (open beds) seedling performance of West Himalayan Alder (*Alnus nitida* Endl.)**

Parameters → ↓Treatments	Germination (%)	Survival (%)	Shoot height (cm)	Root length (cm)	Collar diameter (mm)	Root : shoot ratio (R : S)
Open beds	33.33 (35.229)	61.64 (51.754)	7.7000	9.200	15.300	1.195
Root trainers	38.67 (38.441)	68.84 (56.007)	8.3000	8.100	14.100	0.975
<b>CD<sub>0.05</sub></b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>0.430</b>	<b>0.745</b>	<b>0.172</b>

Figures in parentheses are arc sin transformations



**Fig. 4 :** Effect of collection dates on germination of West Himalayan Alder (*Alnus nitida* Endl.) seeds



Plate-14 : Oldest living West Himalayan Alder trees (*Ainus nitida* Endl.) growing in Kashmir valley



Plate-15 : West Himalayan Alder tree (*Ainus nitida* Endl.) seed germinated after 24 hrs soaking in cold water

percentage of seeds sown in nursery beds was observed to be 33.33 whereas the germination percentage of seeds sown in root trainers was 38.67. For open beds 61.64 per cent survival was recorded which was apparently less than that of root trainers (68.84%) but not significantly lesser than it. A significant difference was observed in average root length, average collar diameter and average root shoot ratio but difference in the average shoot height in both the cases was found to be non-significant. Average shoot height and average collar diameter in case of open beds was recorded as 7.7 cm and 15.3 mm as compared to 8.1 cm and 14.1 mm, respectively for those raised in root trainers. The average root length and average root-shoot ratio for those raised in open beds was 9.2 cm and 1.195, respectively and that of root trainers was 8.1 and 0.975 respectively.

Therefore, studies conducted on raising of seedling nursery in open beds and root trainers revealed that seedlings raised in open beds were much superior to those grown in root trainers with respect to collar diameter, root length and root-shoot ratio.

#### **4.2.3 Vegetative propagation**

Under natural conditions West Himalayan Alder propagates through seed but its natural regeneration is negligible for which seed emptiness is considered to be a major cause. Therefore, an attempt was undertaken to

#### **4.2.3.1 Sprouting**

The effects of auxin treatments on the sprouting per cent of *Alnus nitida* stem cuttings are presented in Table-5.

A perusal of the data indicates that the hormonal treatments have enhanced the sprouting of stem cuttings. The treatment (IBA + NAA 700 ppm) resulted in maximum sprouting (70%). The IBA individually and combination of IBA and NAA increased sprouting significantly and were at par with each other. But NAA, IAA and water were not so effective with respect to sprouting and showed results at par with one another. IBA 1000 ppm (40%) and IBA 700 ppm (50%), NAA 700 ppm (50%) and combination of NAA + IBA 700 ppm (70%) increased sprouting percentage significantly and rest of the concentrations of the used hormones showed results at par with control.

#### **4.2.3.2 Rooting (%)**

The results of rooting as observed on stem cuttings of *Alnus nitida* are given in Table-6 and Plate-18 & 19.

The rooting per cent was greatly influenced by auxin treatments. A comparison of overall effects of the auxin treatments on the rooting of stem cuttings revealed that only few treatments induced rooting in the stem

**Table-5 : Effect of growth regulators on sprouting percentage of West Himalayan Alder (*Alnus nitida* Endl.) stem cuttings**

<b>Levels (ppm) →</b> <b>↓Treatments</b>	<b>400</b>	<b>700</b>	<b>1000</b>	<b>1300</b>	<b>Mean</b>
IAA	10 (13.442)	25 (29.732)	20 (23.171)	10 (13.442)	<b>16.25</b> <b>(19.947)</b>
IBA	25 (29.732)	60 (51.051)	40 (35.272)	20 (23.171)	<b>36.25</b> <b>(34.806)</b>
NAA	15 (16.609)	60 (51.051)	25 (29.732)	10 (13.442)	<b>25.00</b> <b>(27.708)</b>
IBA + NAA	20 (23.171)	70 (57.102)	30 (32.898)	25 (29.732)	<b>36.25</b> <b>(35.726)</b>
<b>Mean</b>	<b>17.50</b> <b>(20.738)</b>	<b>51.25</b> <b>(47.234)</b>	<b>28.75</b> <b>(30.268)</b>	<b>16.25</b> <b>(19.947)</b>	
Control	16.25 (21.586)				

Figures in parentheses are arc sin transformations

**CD at 0.05**

Treatments	:	11.05
Levels	:	9.88
Treatments x Levels	:	N.S

**Table-6 : Effect of growth regulators on rooting percentage of West Himalayan Alder (*Alnus nitida* Endl.) stem cuttings**

<b>Levels (ppm) →</b> <b>↓Treatments</b>	<b>400</b>	<b>700</b>	<b>1000</b>	<b>1300</b>	<b>Mean</b>
IAA	0.0031 (0.320)	5 (12.921)	0.0031 (0.320)	0.0031 (0.320)	<b>1.25</b> <b>(3.470)</b>
IBA	0.0031 (0.320)	15 (22.209)	0.0031 (0.320)	0.0031 (0.320)	<b>3.75</b> <b>(3.99)</b>
NAA	0.0031 (0.320)	15 (22.209)	0.0031 (0.320)	0.0031 (0.320)	<b>3.75</b> <b>(3.99)</b>
IBA + NAA	0.0031 (0.320)	30 (32.898)	0.0031 (0.320)	0.0031 (0.320)	<b>7.50</b> <b>(7.74)</b>
<b>Mean</b>	<b>0.0031</b> <b>(0.320)</b>	<b>16.25</b> <b>(13.922)</b>	0.0031 (0.320)	0.0031 (0.320)	
Control	0.0031 (0.320)				

Figures in parentheses are arc sin transformations

**CD at 0.05**

Treatments	:	1.88
Levels	:	1.68
Treatments x Levels	:	3.77

cuttings of *Alnus nitida* and rest like control could not induce rooting. The cuttings treated with IBA and NAA cocktail at 700 ppm exhibited highest (30%) rooting as against zero per cent in control. The treatment NAA 700 ppm and IBA 700 ppm resulted in 15 per cent rooting and therefore were statistically at par with each other. But IAA 700 ppm resulted in only 5 per cent rooting. Rest of the concentrations alongwith control could not induce rooting. A comparison of overall effect of the auxins irrespective of the concentrations revealed that IBA + NAA cocktail exhibited significantly better results than IBA and NAA individually whose effect with respect to rooting was at par. IAA showed the least effect. Among concentrations, irrespective of hormones only 700 ppm was able to induce rooting.

#### **4.2.3.3 Survival (%)**

The results of survival per cent as observed in the stem cuttings of *Alnus nitida* are given in Table-7.

All the rooted cuttings survived till the end of growing season so the effect of hormone/concentration and their interaction on the survival percentage was non-significant.

#### **4.2.3.4 Shoot height (cm)**

The results on effects of various auxin treatments on the length of shoots are set out in Table-8 and Plate-20.

**Table-7 : Effect of growth regulators on survival percentage of West Himalayan Alder (*Alnus nitida* Endl.) stem cuttings**

<b>Levels (ppm) →</b> <b>↓Treatments</b>	<b>400</b>	<b>700</b>	<b>1000</b>	<b>1300</b>	<b>Mean</b>
IAA	0.0031 (0.319)	99.997 (89.676)	0.0031 (0.319)	0.0031 (0.319)	<b>25.00</b> <b>(22.42)</b>
IBA	0.0031 (0.319)	99.997 (89.676)	0.0031 (0.319)	0.0031 (0.319)	<b>25.00</b> <b>(22.42)</b>
NAA	0.0031 (0.319)	99.997 (89.676)	0.0031 (0.319)	0.0031 (0.319)	<b>25.00</b> <b>(22.42)</b>
IBA + NAA	0.0031 (0.319)	99.997 (89.676)	0.0031 (0.319)	0.0031 (0.319)	<b>25.00</b> <b>(22.42)</b>
<b>Mean</b>	<b>0.0031</b> <b>(0.319)</b>	<b>99.997</b> <b>(89.676)</b>	<b>0.0031</b> <b>(0.319)</b>	<b>0.0031</b> <b>(0.319)</b>	
Control	0.0031 (0.320)				

Figures in parentheses are arc sin transformations

**CD at 0.05**

Treatments : NS  
 Levels : NS  
 Treatments x Levels : NS

**Table-8 : Effect of growth regulators on shoot height (cm) of West Himalayan Alder (*Alnus nitida* Endl.) stem cuttings**

Levels (ppm) → ↓ Treatments	400	700	1000	1300	Mean
IAA	0.0031	18.300	0.0031	0.0031	<b>4.570</b>
IBA	0.0031	17.450	0.0031	0.0031	<b>4.360</b>
NAA	0.0031	18.525	0.0031	0.0031	<b>4.630</b>
IBA + NAA	0.0031	18.925	0.0031	0.0031	<b>4.730</b>
<b>Mean</b>	<b>0.0031</b>	<b>18.300</b>	<b>0.0031</b>	<b>0.0031</b>	
Control	0.0031 (0.320)				

Figures in parentheses are arc sin transformations

**CD at 0.05**

Treatments	:	0.25
Levels	:	0.23
Treatments x Levels	:	0.51

The maximum shoot height (18.925 cm) was recorded in stem cuttings treated with IBA + NAA cocktail at 700 ppm. The NAA 700 ppm showed the shoot height of 18.525 cm which was statistically at par with IAA 700 ppm (18.3 cm) but the lowest shoot height was exhibited by IBA 700 ppm (17.45 cm) treated cuttings. The mean effect of IBA + NAA cocktail at 700 ppm was at par with NAA 700 ppm and that of IBA 700 ppm with IAA 700 ppm.

#### **4.2.3.5 Collar diameter (mm)**

The results on effects of various auxin treatments which caused rooting on the collar diameter of leading shoot are depicted in Table-9.

The maximum collar diameter (17.8 mm) was recorded in the stem cuttings treated with IAA 700 ppm which was at par with IBA 700 ppm (17.6 mm). The effect of these two hormones was significantly higher than NAA 700 ppm and IBA + NAA cocktail at 700 ppm with respect to collar diameter. Also the effect of NAA and IBA + NAA cocktail was at par but showed significantly lesser effect on collar diameter than IAA 700 ppm.

**Table-9 : Effect of growth regulators on collar diameter (mm) of West Himalayan Alder (*Alnus nitida* Endl.) stem cuttings**

<b>Levels (ppm) →</b> <b>↓Treatments</b>	<b>400</b>	<b>700</b>	<b>1000</b>	<b>1300</b>	<b>Mean</b>
IAA	0.0031	17.800	0.0031	0.0031	<b>4.450</b>
IBA	0.0031	17.600	0.0031	0.0031	<b>4.400</b>
NAA	0.0031	17.150	0.0031	0.0031	<b>4.310</b>
IBA + NAA	0.0031	17.050	0.0031	0.0031	<b>4.260</b>
<b>Mean</b>	<b>0.0031</b>	<b>17.40</b>	<b>0.0031</b>	<b>0.0031</b>	
Control	0.0031 (0.320)				

Figures in parentheses are arc sin transformations

**CD at 0.05**

Treatments : 0.12  
 Levels : 0.11  
 Treatments x Levels : 0.24

#### **4.2.3.6 Root length (cm)**

The results on effect of various auxin treatments which caused rooting on the root length of the stem cuttings are shown in Table-10 and Plate-21.

The maximum root length (11.5 cm) was observed in stem cuttings treated with IBA + NAA cocktail at 700 ppm which was at par with NAA 700 ppm (11.35 cm). The IBA 700 ppm showed 11.05 cm root length which was at par with IAA 700 ppm (10.9 cm).

With respect to root length, the effect of all the hormones irrespective of concentrations was at par.

#### **4.2.3.7 Root diameter (mm)**

The results on effect of various auxin treatments which caused rooting, on the root diameter of stem cuttings are illustrated in Table-11.

The maximum root diameter (13.45 mm) was exhibited by stem cuttings treated with IAA 700 ppm which was significantly higher than IBA 700 ppm (12.575 mm), NAA 700 ppm (12.4 mm) and IBA + NAA cocktail 700 ppm (12.45 mm), all of which are at par with each other. Same results are arrived at on analysis of hormones irrespective of concentrations.

**Table-10 : Effect of growth regulators on root length (cm) of West Himalayan Alder (*Alnus nitida* Endl.) stem cuttings**

Levels (ppm) → ↓Treatments	400	700	1000	1300	Mean
IAA	0.0031	10.900	0.0031	0.0031	<b>2.720</b>
IBA	0.0031	11.050	0.0031	0.0031	<b>2.760</b>
NAA	0.0031	11.350	0.0031	0.0031	<b>2.830</b>
IBA + NAA	0.0031	11.500	0.0031	0.0031	<b>2.870</b>
<b>Mean</b>	<b>0.0031</b>	<b>11.200</b>	<b>0.0031</b>	<b>0.0031</b>	
Control	0.0031 (0.320)				

Figures in parentheses are arc sin transformations

**CD at 0.05**

Treatments	:	0.15
Levels	:	0.14
Treatments x Levels	:	0.31

**Table-11 : Effect of growth regulators on root diameter (mm) of West Himalayan Alder (*Alnus nitida* Endl.) stem cuttings**

Levels (ppm) → ↓Treatments	400	700	1000	1300	Mean
IAA	0.0031	13.450	0.0031	0.0031	<b>3.360</b>
IBA	0.0031	12.575	0.0031	0.0031	<b>3.140</b>
NAA	0.0031	12.400	0.0031	0.0031	<b>3.100</b>
IBA + NAA	0.0031	12.450	0.0031	0.0031	<b>3.110</b>
<b>Mean</b>	<b>0.0031</b>	<b>12.710</b>	<b>0.0031</b>	<b>0.0031</b>	
Control	0.0031 (0.320)				

Figures in parentheses are arc sin transformations

**CD at 0.05**

Treatments	:	0.11
Levels	:	0.10
Treatments x Levels	:	0.23



Plate-16 : West Himalayan Alder tree (*Alnus nitida* Endl.) seedling nursery in open beds



Plate-17 : West Himalayan Alder tree (*Alnus nitida* Endl.) seedling nursery in root trainers



Plate-18 : West Himalayan Alder tree (*Alnus nitida* Endl.) rooted stem cuttings in polybags



Plate-19 : West Himalayan Alder tree (*Alnus nitida* Endl.) rooted stem cuttings after preconditioning and PGR treatment



Plate-20 : West Himalayan Alder tree (*Alnus nitida* Endl.) shoot of rooted stem cuttings after preconditioning and PGR treatment



Plate-21 : West Himalayan Alder tree (*Alnus nitida* Endl.) root of rooted stem cuttings after preconditioning and PGR treatment

### **4.3 Vegetative propagation of West Himalayan Alder (*Alnus nitida* Endl.) through treated softwood cuttings**

Softwood cuttings raised in polybags after being treated with PGRs viz. IAA, IBA, NAA and IBA + NAA cocktail at concentrations of 400, 700, 1000 and 1300 ppm, each given a quick dip for 30 seconds did not root. Although good number of cuttings sprouted but no cutting was able to produce roots. The average length of sprouts recorded was 3.5 cm which survived for about 35-45 days.

## **CHAPTER – 5**

### **DISCUSSION**

Forests and trees are of critical importance for most rural people in the developing world. These provide a principal source of energy and building materials, help maintain environmental stability, yield products that increase food security and furnish a source of off-farm income and employment. Yet people do not benefit as much as effectively as they could, from forests and trees in the struggle against hunger, natural resource degradation, energy shortage and poverty. To make this possible scientists are seriously engaged in identifying suitable alternatives and exploit promising indigenous species which can increase productivity and biomass substantially. *Alnus* is one of such species which has shown scope in this regard.

*Alnus* is one of the largest genera and there are as many as 35 species of *Alnus* in the world (Mebberley, 1989). Alders exhibit a wide diversity and occupy a variety of climatic conditions throughout their natural range. Alder is confined to North-Western Himalayas from the Yamuna westwards ranging from 900 to 2700 m (Troup, 1921). It is one of the actinorhizal plants with trees of a size suitable for large timber. It is a pioneer species that colonizes newly disturbed sites. It is commonly found

in rivarian areas, avalanche tracks and ridges. It improves soil fertility by increasing soil nitrogen, organic matter and cation-exchange capacity. Probably the oldest use of Alders is for fire wood. Alders also have found a ready place in the paper industry. It can play a role in regional biomass energy programmes.

It is important to mention here that Indian Alders are very sparingly studied species and practically very little work has been done on it. In valley too, it has not received any attention so far, therefore, no information is available with respect to its status, distribution, propagation etc. in the Kashmir valley. Hence the present study was undertaken to collect some basic information about various aspects related to the species. The main objectives of the investigation were :

- To study status and distribution of Alder tree in Kashmir valley
- To study propagation of Alder (*Alnus* sp.)

The results obtained on these aspects have been discussed in the ensuing pages.

### **5.1 Status and distribution of West Himalayan Alder in Kashmir valley**

In order to achieve the first objective i.e. status and distribution of Alder tree in Kashmir valley, an extensive survey of all the districts of

Kashmir valley was undertaken. Following studies were undertaken to meet the objective :

### **5.1.1 Species identification**

In the first instance efforts were made to identify various species of genus *Alnus* growing in Kashmir valley. Identification was made on the basis of various phenological and morphological characteristics of the species e.g. shape and size of leaves, colour of flowers, seeds, bark etc. An attempt to find its vernacular name (Kashmiri name) was also made.

Extensive survey conducted revealed that only one *Alnus* species was found growing in the valley and was identified as *Alnus nitida* (Endl.). It is a large semi-deciduous tree with a straight trunk and spherical but spreading crown of dark green foliage. Its average height recorded was about 35 m and average DBH of about 180 cm. The stem bark was grey with longitudinal furrows but in the pole stage the bark was reddish brown thin and smooth often with yellowish patches and short, raised lenticels. The leaves 10-12.5 cm long, 2-8 cm wide were alternate, elliptical and acuminate and crenate. The upper leaf surface was dark green but the lower surface was pale green. Leaves were shed from December-January and new flush of leaves developed in the month of February-March so deciduous period was for a very short period and thus can be described as semi-

deciduous. Narrowly cylindrical clusters of male catkins 4-10 inch long and green in colour appeared at the end of twigs by July-August and turned yellow by August-September. Female catkins much shorter, erect and woody occurred on branching side twigs separately on the same or different twigs at the same time but achieved full development only after pollination in August-September. The fruits which superficially resembled cones of the pine family were dark brown, elliptical, composed of many spreading hardwoody scales. Seeds were shiny brown, circulate and flat with two broad membranous wings more than 2 mm across. Empty cones persisted on the trees for a very long time.

The phenological and morphological observations recorded revealed that the *Alnus* species growing in the valley was similar to that of *Alnus nitida* as described and reported earlier by Troup (1921) and after an extensive study for a period of about 3 years, it was observed that the trees present here do not show any type of variation from the ones described by Troup (1921). So far the vernacular name (Kashmiri) is concerned, it is called 'Champ' in Srinagar, 'Zamp' in Banihal, Ramban etc. and 'Sarol' in Poonch, Rajouri etc. Since the valley of Kashmir is enclosed in a chain of mountainous ring therefore dispersal of its seeds from these areas towards

Kashmir valley is almost nil and probably the main reason for its absence in the valley.

While conducting survey in the Kashmir valley, it was found that people were hardly aware about the tree as it is rarely found in the valley and thus apart from the use as fire wood, hardly any other use of it was known to locals. However, elsewhere there are reports of its multifarious uses. Alder tree is a major fuel wood species in its range and is generally encouraged in energy plantation (Vimal and Tyagi, 1984). Its heat content is comparable to Red Alder (*Alnus rubra*) 600 K cal/kg (Anonymous, 1980). It has good, even burning characteristic and has been used as firewood species since time immemorial. The species is extensively used in the manufacture of plywood; pencil slates, black boards, bobbins, packing cases and tea boxes etc (Anonymous, 1980). The bark contains 7 per cent tannins and is used in dyeing to deepen the colour of *Rubia cordifolia* (Anonymous, 1972). The young twigs are used for tying the loads, rope bridges and in the construction of baskets. It has also medicinal importance. It is very good astringent and a decoction of the bark is applied externally to treat swelling and body pains.

The wood is soft, even grained, hard to cut and is used for construction of furniture. Alders are described as commercial timbers

(Pearson and Brown, 1932). The fresh leaves and cones are used as fodder occasionally (Laure, 1945). It is a pioneer species for afforestation of land slips and fresh cuttings in hill slopes and degraded habitats with low fertility levels (Luna, 1996). These are primary successional species forming *Alnus poplus* community on newly formed sites on the river banks (Puri, 1960). Considering such diverse uses of the species it may predicted that it might have been present abundantly in the valley in past but people might have used it drastically for various purposes resulting in to its extinction.

### **5.1.2 Status and distribution**

During the course of survey observations with respect to its status, distribution, concentration and identification of old existing Alder trees in the area were also recorded. The species was found to be growing in the Srinagar district only at restricted places viz., Theed Harwan and Sonawar. The total number of trees present in Harwan were only three and the same trees were the oldest (127 years approximately) ones in the valley. About its origin two schools of thought prevailed in the area. One school of thought believed that the tree was indigenous to the valley and were growing abundantly in the past and due to their indiscriminate felling for their use as fuel wood they had turned rare and endangered and thus only three trees are

surviving in the valley. This view is supported by Centre of Research for Development/PG Department of Environmental Science, University of Kashmir, Srinagar.

According to another school of thought, these trees were not indigenous to the valley and have been raised from seed brought from outside in the 19<sup>th</sup> century by some English Silviculturists. What so ever may be the fact but one cannot deny that Kashmir conditions are very much feasible for the Alder plantations. This has been amply proved by the state forest department by raising Alder seedlings at Sonawar from its seed and through the present study by accomplishing successfully the second objective of the project i.e. Propagation of Alder in Kashmir Valley.

The trees is however abundantly found in other parts of J&K especially along the banks of river chinab, Ramban, Chinani, Batote, Punch, Rajouri etc. One of the reasons for its absence in the valley may be the insufficient levels of dispersal of viable seeds of the species due to the absence of Alder plantation in the valley and because of the enclosure of the valley by the chain of mountainous ring obstructing the seed dispersal from outside into the valley

## **5.2 Propagation of West Himalayan Alder**

In order to achieve this objective, studies were undertaken to determine :

- Maturity indices
- Raising of seedling nursery
- Vegetative propagation through treated hardwood and softwood cuttings

### **5.2.1 Maturity indices**

The knowledge of exact stage and time of seed maturity is essential for collection of abundant quantity of healthy and vigorous seeds (Troup, 1921). In order to determine the optimal time for seed collection of West Himalayan Alder tree (*Alnus nitida* Endl.) the cones were collected from the available trees after every 15 days of interval from 1<sup>st</sup> of October till their maturation. The data collected and presented in the Table shows that various parameters of maturity recorded on different collection dates had a significant effect on the germination percentage of the Alder seeds.

#### **5.2.1.1 Fruit/Seed colour(Ocular)**

Studies conducted revealed that West Himalayan Alder tree (*Alnus nitida* (Endl.) comes into flowering in the month of July-August and these

flowers remain on the tree for 2-3 months but for most of the period they remain green and therefore their appearance do not have any profound effect on the general appearance of the tree during flowering. Male catkins initially green turn yellow on maturation and after pollen dispersal turn brown leading to their fall finally. Female flowers/fruits which are in the form of cones attain full development after pollination in September but colour change from green to brown starts in November and by the end of December turn chocolate brown in colour.

After pollination in September the development of seeds become apparent and by October they are papery and creamy white. Afterwards it starts turning brown and by the end of December it completely turns shiny chocolate brown. Thus by the end of December both cones and seeds turn brown signifying the appropriate time for its seed collection. In Alder colour of cone/seed should be considered as an index of ripeness because maximum germination percentage was recorded only when the colour of the cone/seed was brown but care should be taken that cones are collected before the seed dispersal to avoid wastage of seed and achieve maximum collection of most healthy and mature seeds as they are first to be dispersed. It is seen that empty cones remain on trees after dispersal of healthy seeds for a long time. The seeds from cones persisting on the trees for a long time

are usually empty and therefore useless.

Colour change in fruit/seed coat has been a common method for detecting the maturity of seeds in many forest tree species. Change in colour of fruits in junipers to deep blue have been reported by Stoeckler and Slabaugh (1965). Change in colour of cone and seeds of deodar towards maturity has been reported by Mughal and Thapliyal (2006). More or less similar results have been reported by various workers for different species e.g. in *Liquidambar styraciflua* and *Platanus occidentalis* (Bonner, 1972), *Quercus* spp. (Bonner, 1974, 1976), *Carissa opaca* and *Ficus benjamina* (Maithani *et al.*, 1987), *Gmelina arborea* (Mindawati and Rohayat, 1994) and *Azadirachta indica* (Pukittayacamee *et al.*, 1995),

#### **5.2.1.2 Fruit/seed weight**

Initially at the first collection date (1<sup>st</sup> of October) when the fruit colour was green, the average weight of fruits was measured as 2.57 g. It attained maximum average weight of 2.98 g in the month of November. From November onwards weight of the fruit started changing conspicuously due to pronounced colour change from green to brown. It decreased to 1.78 g on 31<sup>st</sup> December after seed dispersal. During the growing season from October to mid-November the fruit weight increased,

however from mid November onwards loss of moisture led to decrease in its weight.

Seed weight also varied from time to time and showed similar pattern as that of fruit weight. On the first collection date, the seeds were not so apparent, therefore, seed weight could not be taken but on the 2<sup>nd</sup> date of collection, the 1000-seed weight had reached to about 2.01 g. The seed weight reached to its maximum (3.2 g) on 15<sup>th</sup> December and afterwards started to decrease. Thus, it can be seen that the seed weight continue to show increasing trend even after the fruit weight started to decrease. This may be due to continuous nutrient allocation to the seeds for a very long time.

Increase in seed weight and size is a function of resource allocation. During the developmental phase from October to mid November the increase in the weight of fruit/seed may be attributed to the synthesis of biochemicals in the endosperm and cotyledons of seeds and to the translocation of nutrients from plant tissues to seed/fruit. However, the decrease in fruit/seed weight may be attributed to desiccation due to moisture loss in the later period of growth which is the characteristic feature of maturity. Similar findings were obtained by Mughal and Thapliyal (2006) who reported that germination percentage increased with the

increase in seed weight in *Cedrus deodara*. Relative high seed weight is often desirable since it is correlated with rapid germination and good seedling establishment (Griffin, 1972, Sorensen and Campbell, 1993).

Same developmental phase have been based on a number of studies undertaken on various crops by Dure (1975), Bewley and Black (1983, 1985), Noggle and Fritz (1983) and many other.

### **5.2.1.3 Specific gravity (fruits)**

The specific gravity of West Himalayan Alder fruits decreased from 0.99 (immature fruits) to 0.656 with maturity of seeds. No germination (0%) was recorded when specific gravity of seed was 0.99 and 0.96 (maximum) and fruits were green and immature. However, the maximum germination per cent of 42 was recorded when specific gravity was 0.727 and colour of the seed/fruit was brown with green patches. Thus specific gravity and germination percentage had a negative correlation i.e. germination percentage increased with the decrease in specific gravity of the fruit. Similar results have been observed in a number of forest tree species. Singh and Kachari (2006) studied the relationship of germination percentage and specific gravity in *Pinus kesia* and reported that germination percentage increased with decrease in specific gravity of cones. Similarly, in Spruce specific gravity was minimum at maturity (Singh, 1989). Studies

showing increase in seed germination with decrease in specific gravity have also been carried out in some other tree species (Maki, 1940 and Oliver, 1974).

#### **5.2.1.4 Germination (%)**

It is an admitted fact and has been established with almost all the forest tree species that maturity of seed and germination is correlated. Seed germination per cent increases as the fruit matures and is maximum when the fruit/seed is fully mature. This is probably as a result of synthesis of carbohydrates, fats and proteins and allocation of nutrients to seeds from plant tissues which proceed gradually across the seasons to maturity and is commonly defined by germinability.

The studies on the germination of Alder seeds under laboratory conditions revealed the maximum germination (42%) was observed for the last two collections made on 15<sup>th</sup> of December and 30<sup>th</sup> of December when specific gravity of fruit/seed, seed weight, fruit weight were lowest and colour of the seed coat was shinny chocolate brown.

Singh (1998) observed increase in germination per cent from 0.5 to 32.14 in seeds of fir (*Abies pindrow*) when collected in August to October. Similarly studies conducted on seed germination and seedling establishment in natural forest of spruce and silver fir in Kotgarh (H.P) showed that seed

dispersed in October had lower germination percentage than seeds dispersed in November (Singh, 1998 and Singh, 1989).

The studies conducted on maturity indices therefore, revealed that the proper stage of harvesting, the Alder fruits in Kashmir valley was when fruit colour is brown with maximum decline in specific gravity and seed/fruit weight. The maximum of 42 per cent germination was therefore, recorded on 15<sup>th</sup> of December. The low value of germination per cent (42) is probably due to low percentage of purity of West Himalayan Alder seeds.

### **5.2.2 Raising of seedling nursery**

Forest plantations are a powerful tool in the continuing efforts of foresters to increase productivity – the only means of reconciling the increasing demands of forest products and services on the one hand with a decreasing land available for forest tree on the other. Plantations also offer the means of using on large scale the genetically improved material developed by tree breeders. With a few exceptions like poplars and willows, trees are generally propagated from seeds and the suitability and quality of the seeds have a major role on the success of plantation raised thereof. The use of sound seeds from stands of high inherent quality is widely recognised as the best means of ensuring fast growth and healthy plantations capable of yielding high quality wood (Aldhous, 1972).

Studies conducted on nursery raising of West Himalayan Alder revealed that no significant difference was observed with respect to germination, survival and seedling height when seeds were sown in open beds and root trainers. However, significant differences were observed with respect to collar diameter, root length and root shoot ratio. The seedlings raised in open beds exhibited maximum collar diameter (15.3 mm), maximum root length (9.2 cm) and maximum root-shoot ratio (1.195). However, the seedlings raised in root trainers exhibited the collar diameter equal to 14.1 mm, root length equal to 8.1 cm and root shoot ratio of 0.975.

The increased collar diameter and root length and thus more root shoot ratio in seedlings raised in open beds may be probably due to abundant space available to root system for drawing moisture and nutrients whereas root trainers provided lesser space for root development and thus help in more resource allocation to shoots. It may also be probably due to environmental conditions especially temperature and the medium used in root trainers (soil : sand : FYM :: 2:1:1). Since root trainers of one size and one combination were used in the present study, therefore, their performance cannot be ignored and study needs to be carried out to find out suitable medium and container size. Similar results have been reported by Mughal (1996) who achieved optimum shoot and root development when

*Cupressus torulosa* and *Cedrus deodara* seedlings were raised in open nursery beds and significantly lesser shoot and root development was achieved in polypacks. Also, Misra and Jaiswal (1993) obtained maximum survival, height and collar diameter in seedling raised in bigger size of polybags. Sutherland and Day (1988) reported increase in seedling growth with increase in volume of containers.

### **5.2.3 Vegetative propagation of West Himalayan Alder tree (*Alnus nitida* Endl.) through PGR treated cuttings**

The vegetative propagation and development of clones with outstanding characteristic has been commonly used in agriculture for many years particularly in woody perennial cash crops. However, the technology for producing clonal planting stock in the numbers needed for commercial forest plantation establishment is relatively new. The main advantage of the vegetative propagation is that the selected individuals of many species can be multiplied in an infinite number of plants and plantations with a high degree of homogeneity. In utilising these techniques for tree improvement research, whether provenance selection, progeny testing or hybridization can be immediately capitalised and used in tree plantation establishment.

The value of vegetative propagation in forest is well understood. It is easiest, convenient and economical method of production. Also transfer of non-additive characteristics through seed is difficult. However, it is

routinely possible through vegetative propagation. Therefore this can be used for achieving gains such as growth, which has low heritability. The constraints in this approach pertain to biological problems related to maturation state of donor plants, cutting environments, the condition of cuttings and survival/growth of cuttings.

In the present study the effect of various PGRs (IAA, IBA, NAA and NAA + IBA cocktail) at the concentrations of 400, 700, 1000 and 1300 ppm each was studied in hardwood and softwood cuttings in different seasons.

In the first trial laid in March 2007, hardwood cuttings were collected from the available trees from Harwan, Srinagar and after preconditioning and treating with above mentioned PGRs at the captioned concentrations for 24 hours were planted both in open beds and polybags. In this trial cuttings failed to root in open beds as well as polybags. However, some results in terms of sprouting percentage were achieved. The average length of the sprout recorded was 3.0 cm which survived for about 60 days. The failure of the cuttings to root may be attributed to the factor that the selected concentrations of PGRs do not suit the species or may be due to the factor that these cuttings were collected from very old aged available Alder trees of Harwan, Srinagar which might have lost the rejuvenation power.

In the 2<sup>nd</sup> trial laid in August, 2007 the juvenile (current year growth) softwood cuttings were collected and after giving quick dip treatments of above mentioned PGRs at above captioned concentrations for 30 seconds were planted in polybags of size 7"x 5" and were kept in shade. Although a good number of cuttings sprouted but no cutting was able to produce roots. The average length of the sprouts recorded was 3.5 cm which survived for about 35-45 days. This time the failure of the cuttings to root may be attributed to the prevailing high temperature during this season resulting in the desiccation of highly succulent softwood cuttings, also may be quick dip must have been given to them at higher concentrations or once again may be due to the factor that these cuttings were also collected from very old aged available trees of Harwan, Srinagar.

In the 3<sup>rd</sup> trial laid in March 2008, hardwood cuttings were collected from young (3-4 year old) trees from Ramban and after treating with given concentrations of above mentioned PGRs for 24 hours and after pre-conditioning them by removing some portion of bark in the form of ring (3 mm) at a length of about 2.5 cm from the basal end, were planted both in open beds and polybags. In this trial cuttings failed to root in open beds, however, some results in terms of sprouting percentage were achieved. Out of various treatments, IAA 700 ppm, IBA 700 ppm, IBA 1000, NAA 700

and IBA + NAA cocktail 700 ppm showed 20, 35, 30, 40 and 45 per cent sprouting respectively as against 20 per cent in control. The overall average sprout length was equal to 4.5 cm. In the same experiment the cuttings treated with same hormones at above mentioned concentrations and planted in polybags of size 7" x 5" containing soil, sand and FYM in the ratio of 2:1:1 and kept in shade showed prominent results with respect to sprouting and rooting. The effect of PGRs on aerial characteristics and rooting behaviour of these cuttings was recorded and has been presented in Tables-5-11.

It was seen that response of various treatments towards sprouting was varied. The IBA and NAA cocktail at 700 ppm showed maximum sprouting (70%), followed by IBA 700 ppm (60%), NAA 700 ppm (50%) and IBA 1000 ppm (40%). Out of the treatments used only 700 ppm of each hormone was able induce rooting. Maximum rooting (30%) was showed by IBA + NAA cocktail at 700 ppm followed by NAA 700 ppm (15%), IBA 700 ppm (15%) and IAA 700 ppm (5%). All the cuttings which rooted survived till the end of growing season so there was not any significant effect of hormones on survival percent of rooted cuttings. Maximum shoot height (18.925 cm) was obtained in NAA + IBA cocktail 700 ppm followed by NAA 700 ppm (18.525 cm), IAA 700 ppm (18.3 cm) and IBA (17.45

cm). Similarly maximum collar diameter was obtained in IAA 700 ppm (17.8 mm) followed by IBA 700 ppm (17.6 mm), NAA 700 ppm (17.15 mm) and IBA + NAA cocktail at 700 ppm (17.05 mm). Maximum root length was recorded in IBA + NAA cocktail at 700 ppm (11.50 cm) followed by NAA 700 ppm (11.35 cm), IBA (11.05 cm) and IAA 700 ppm (10.9 cm). Maximum root diameter (13.45mm) was recorded in IAA 700 ppm treated cuttings followed by IBA 700 ppm (12.575 mm) IBA + NAA cocktail at 700 ppm (12.45mm) and NAA 700 ppm (12.40 mm).

On the basis of the study it can be concluded that any hormone used at 700 ppm can induced rooting in *Alnus nitida* stem cuttings and none was able to induced rooting at concentrations other than 700 ppm. Keeping the overall effect of hormones on sprouting, rooting and aerial characteristics in view it is concluded that IBA + NAA cocktail at 700 ppm is the best plant growth regulator for vegetative propagation of West Himalayan alder under existing conditions.

Though it has been reported many a times that auxins, natural or artificial, trigger root initiation process and are required for initiation of adventitious roots on stem cuttings, there is very little attempt to explain the nature of its effect (Gautheret, 1969). Auxins play multifarious roles related to the division and elongation of meristem, differentiation of cambial

initials into root primordia and the mobilisation of reserve food materials by enhancing the activity of hydrolysing enzymes. Role of auxins in enhancing the callosing and rooting has been reported by Houseley and Bentley (1956); Haissig (1971); Nanda *et al.* (1970) and Loach (1988). According to Kralik and Sebanek (1983). Auxins treatment cause considerable cell elongation and proliferation in cortex, phloem and cambium and results in breakage of continuous sclerenchymatous rings. According to Haissig (1974, 1982), auxins induce hydrolysis and mobilisation of nutritional factors to the site of application, promoting thereby root initiation. Haissig (1986) observed that increased hydrolytic activity due to applied auxins resulted in higher rooting percent in the cuttings.

Preconditioning studies have shown that maximum rooting occurred in ringed cuttings, which was significantly better than the unringed ones. Besides mean rooting, number of roots and root length were also higher in ringed cuttings. Preconditioned cuttings in *Celtis australis* and *Grewia optiva* have been reported to greatly improve the mean rooting (Singh and Kumar, 1974). Hare (1977) found more rooted cuttings and longer root system in ringed cuttings of *Pinus elliottii*. Again the present findings are in general in conformity to those of Dhua and Sen (1982) who also obtained very high rooting success in ringed cuttings of litchi with 5000 ppm IBA,

besides significant promotion in root number and root length. Further high success in rooting obtained by Debnath *et al.* (1986) in ringed cuttings of lime also supported the findings of the present study. Rooting in ringed cuttings may largely be ascribed to changed physiological conditions brought about by increased carbohydrates, C/N ratio, total phenols, RNA content and more activity of polyphenol oxidase and preoxidase and reduced level of nitrogen in the ringed cuttings.

Sen *et al.* (1967) suggested that changed physiological status of the regenerating tissues consequent upon preconditioning is an important condition in the formation of roots in the relatively difficult to root species. Gowda (1983) attributed improved rooting in tamarind layers due to enhanced biochemical status generated by ringing.

Probably few of these conditions have triggered in ringed cuttings of the present study resulting in rooting.

## CHAPTER – 6

### SUMMARY AND CONCLUSION

*Alnus nitida* Endl. locally known as champ is one of the important broad leaved tree species of western Himalayas and therefore commonly known as West Himalayan Alder. It belongs to family Betulaceae. In Kashmir it is found in Srinagar only. This tree has got multifarious uses but due to its absence in the valley very less is known to people about its uses, methods of propagation etc. Because of the lack of the basic information about the tree, it has not been used to its fullest potential in the valley, therefore to fill this gap, current studies entitled “Status and propagation of Alder (*Alnus* spp) tree in the Kashmir valley” was undertaken and carried out at the Faculty of Forestry, SKUAST-K, Shalimar during the year 2007 and 2009 with the following main objectives:

- i. To study status and distribution of Alder in Kashmir valley.
- ii. To study propagation of Alder.

Summary of the results obtained after the said study are as follows:

- Detailed survey conducted revealed that only one *Alnus* species was found growing in the valley. On the basis of phenological

characteristics the species has been identified as *Alnus nitida* Endl.

- It is a large semi-deciduous nitrogen fixing tree with a straight trunk and spherical but spreading crown. Leaves are elliptical, ovate, acuminate, crenate and alternate. Bark is dark grey with longitudinal furrows. Male catkins appear as narrowly cylindrical clusters, initially green and later turn yellow. Female catkins are cone like and so is its fruit.
- The tree has been observed to be surviving only in Srinagar district that too at two sites only i.e. Theed Harwan and Sonawar. The oldest trees three in number were found in Theed Harwan. The average age was worked out to be about 127 years with approximate average height of 35 metres and approximate average DBH of 180 cm.
- The studies conducted on maturity indices revealed that seeds become mature by middle of December having seed coat colour as shiny chocolate brown with cone specific gravity (0.727), 1000-seed weight (3.2 g) and cone weight (2.43 g) and maximum germination percentage of 42.

- The seeds do not exhibit any kind of dormancy but lose viability in six months.
- Studies conducted on nursery raising of West Himalayan Alder revealed that no significant difference was observed with respect to germination, survival and seedling height when seeds were sown in open beds and root trainers. However, significant differences were observed with respect to collar diameter, root length and root shoot ratio. The seedlings raised in open beds exhibited maximum collar diameter (15.3 mm), maximum root length (9.2 cm) and maximum root-shoot ratio (1.195). However, the seedling raised in root trainers exhibited the collar diameter equal to 14.1 mm, root length equal to 8.1 cm and root shoot ratio of 0.975.
- Studies conducted on vegetative propagation of West Himalayan Alder through treated stem cuttings revealed that IBA + NAA combination at 700 ppm is the best plant growth hormone for its vegetative propagation under existing conditions.
- Softwood cuttings which were also treated with PGRs viz. IAA, IBA, NAA, IBA/NAA combinations at 400, 700, 1000, 1300

ppm by giving quick dip in the month of July failed to root.

However, studies need to be explored further.

## **CONCLUSION**

Only one *Alnus* species was found growing in the valley and the same has been identified as *Alnus nitida* Endl. Tree (West Himalayan Alder Tree). The tree was found growing at restricted places only in Srinagar district of Kashmir valley. Some old trees were located in Theed Harwan and few young Alder plants were found in Sonawar. The three trees found in Harwan, Srinagar were also the oldest living trees of the Kashmir valley. By the presence of these three old trees in Harwan, it may be concluded that the tree does not grow naturally in the Kashmir valley and might have been sporadically introduced in the Kashmir valley long before and the species has failed to flourish here naturally. These trees have survived in this area because of the protection measures taken by the local people and an NGO namely Unjuman-i-Falahi Islam. The presence of few young plants in Sonawar amply proves that the tree species can be raised successfully from seed after proper care and attention in earlier years. The tree has already been declared as endangered and heritage tree but we need to take steps to make them part of various plantation drives especially for the plantation of moist degraded tracts and newly exposed soils to increase their number in

the Kashmir valley to the limit where it can perpetuate itself naturally. Being a non-leguminous nitrogen fixing species, it thrives well on such soils and thus can prove an asset for this purpose. Furthermore, as the tree is non-leguminous nitrogen fixing tree and is having multifarious uses, thus can be also recommended as an agroforestry tree species although other management studies need to be carried out.

On the basis of studies conducted it is recommended that seeds should be collected by the end of December when the colour of both cones and seed turn chocolate brown indicating their maturity. The seeds do not possess any dormancy but their percentage of purity is very low.

Seeds sown in open beds perform better with respect to several characteristics as compared to root trainers so we may conclude that open beds should be used to raise its seedlings. It is also economical.

Preconditioned hardwood cuttings treated with IBA + NAA @ 700 ppm in wet formulation produced better results with respect to several above ground and below ground characteristics, therefore, it may be concluded that IBA + NAA cocktail @ 700 ppm in wet formulation should be used for vegetative propagation of West Himalayan Alder trees through hardwood stem cuttings.

## **Recommendations**

- Oldest trees identified should be declared heritage trees and measures should be taken to protect them.
- Steps should be taken to raise its plantation artificially upto the limit where it can perpetuate itself naturally.
- Because of its ability to grow on inorganic moist soils successfully, it should be declared a social forestry tree and should be used in riverside and canal plantation programmes.
- Being a pioneer species it can be used in various reclamation programmes to afforest degraded areas and newly exposed soils.
- Being non-leguminous nitrogen fixing tree and multipurpose species, it should be recommended as an agroforestry tree species after proper interaction studies with other plants and crops.
- The standardized propagation techniques for Kashmir valley worked out through this project should be made use of during its propagation and same should be disseminated to the concerned departments.
- Its multifarious uses should be highlighted in common masses so that they get motivated to plant it.

It was first work of it's for the species, some more works covering various other aspects about the species should be started so that we can get comprehensive knowledge about the tree species.

## LITERATURE CITED

- Aiazzi, M.T., Arguello, J.A. and Rienzo, J.A. 1988. Physiological maturity in seeds of *Altriplex cordobensis* correlation with visual indicators. *Seed Science and Technology* **26**: 347-350.
- Aldous, J.R. 1972. Nursery practice. Forestry Communication Bulletin No. 43, London, 5-17 pp.
- Allen, G.S. 1958a. Factors affecting the viability and germination of coniferous seed. Part-I. Cone and seed maturity. *Tsuga heterophylla* (Rafn.). *Forest Chronology* **34**: 266-274.
- Allen, G.S. 1958b. Factors affecting the viability and germination of coniferous seed. Part-II. Cone and seed maturity. *Tsuga menziessi* (Mirb.). Franco. *Forest Chronology* **34**: 275-282.
- \*Allsop, F. 1950. Propagation of *Pinus radiata* by means of cuttings. *New Zealand Forest Service Research Notes* **1** : 1-17.
- Anonymous, 1972. A Dictionary of the Economic Products of India. Periodical Express, 42-D Vivek Vihar, Shahadra, Delhi, India.
- Anonymous 1976. A Dictionary of the economic products of India.
- Anonymous, 1980. Firewood crops, shrubs and tree species for energy production. N.A.S., Washington, D.C.38p.
- \*Anonymous, 2010. <http://www.tribuneindia.com.2010/J&K>.
- Barnett, J.P. 1979. Maturation of tree seeds. **In** : *Proceedings of a Symposium on 'Flowerings and Seed Development in Trees*, pp 272-

280. South Forest Experimentation Station, Mississippi State University, IUFRO.

Bewley, J.D. and Black, M. 1983. Physiology and Biochemistry of seeds in relation to germination. Vol. I. Springer-Verlag, Berlin.

Bewley, J.D. and Black, M. 1985. Seeds Physiology of Development and Germination, 1<sup>st</sup> Edn. Plenum Press, New York.

Bhat, G.M., Khan, M.A. and Mughal, A.H. 2007a. Seed maturity indices in Elm (*Ulmus wallichiana*, Planchon): A multipurpose tree species of Kashmir valley. *International Journal of Ecology, Environment and Conservation* **13**(3): 473-476

Bhat, G.M., Khan, M.A. and Mughal, A.H. 2007b. Container reared and nursery reared seedlings of Elm (*Ulmus wallichiana*, Planchon). *Environment and Ecology* **25S**(1): 243-244.

Bonner, F.T. 1972. Maturation of cones of sweet gum and American sycamore seeds. *Forest Science* **18**: 223-231.

Bonner, F.T. 1973. Timing collections of samaras of *Fraxinus pennsylvanica* in March in the Southern United States. **In:** 'Seed Processing' *Proc. Symposium IUFRO WKG. Group on Seed Problems, Bergen*, Vol. I, Paper 4.

Bonner, F.T. 1974. Maturation of acorns of cherry bark, water and willow oak. *Forest Science* **20**: 238-242.

Bonner, F.T. 1976. Maturation of schumard and white oak acorns. *Forest Science* **22**: 149-154.

- Ching, T.M. 1960. Seed production from individual cone of grand fir (*Abies grandis* Lindl.). *Journal of Forestry*. **58**: 959-961.
- \*Cram, W.H. and Worden, H.A. 1957. Maturity of white spruce cones and seed. *Forestry Science* **3** : 263-269.
- Danell, K., Eliasson, L. and Onbly, I. (1980). Condition for rooting of leafy cuttings of *Alnus incana*. *Physiologia Plantarum* **49**(2) : 113-116.
- Debnath, S., Hare, J.K., Dhua, R.S. and Sen, S.K. 1986. Auxin synergists in the rooting of stem cuttings of lime (*Citrus aurantifolia*). *Progressive Horticulture* **18**(1/2) : 60-64.
- Deuber, C.G. 1942. Vegetative propagation of eastern white pine and other five-needled pines. *Journal of Arnold Arboretum* **23** : 198-215.
- Dhua, R.S. and Sen, S.K. 1982. Root regeneration in litch (*Litchi chinensis* Sonn.) stem cuttings with auxin and auxin synergists under intermittent mist. *South Indian Horticulture* **30**(3) : 188-190.
- Dure, L.S. III. 1975. Seed formation. *Annual Review of Plant Physiology* **26**: 259-278.
- Fenton, R.H., Sucoff, E.I. 1965. Effect of storage treatments on the ripening and viability of Virginia pine seeds. *USDA Forest Series Research Notes* **31** : 1-6.
- Fielding, J.M. 1969. Factors affecting rooting and growth of *Pinus radiata* cuttings in the open nursery. *Bulletin of Commonwealth Australian Forestry and Timber Bureau* **45** : 36.

- \*Fowells, H.A. 1949. An index of ripeness for sugar pine seed. USDA. *For. Serv. Forest and Range Exp. Sta. Res. Note*, **64**: 1-5.
- \*Gautheret, R.J. 1969. Investigation on the root formation in the tissue of *Helianthus tuberosus* cultured *in vitro*. *American Journal of Botany* **56** : 702-717.
- Gera Mohit., Bhandari, A.S. and Singh, T. 2001. Quality of seedlings raised in root trainers under semi-arid conditions of central India *Indian Forester* **127**(2): 743-748.
- Ghosh, R.C. and Ansari, A.S. 1971. Local volume tables of plantation species in North Circle (Hill Region). Vol. II, Plantation-Part 1. Bulletin No. 31, Chief Conservator of Forests, West Bengal, pp 107.
- Gill, N.T. 1938. The viability of weed seeds at various stages of maturity. *Annual Applied Biology* **23**: 447-456.
- Gomez, K.A. and Gomez. A.A. 1984. Statistical Procedure for Agricultural Research. 2nd edition. John Wiley and Sons. New York, 680 p.
- Gowda, N. 1983. Studies on vegetative propagation of tamarind (*Tamarindus indica* L.) by air-layering. *Thesis Abstract CSHAU* **9**(3) : 270-271.
- Griffin, A.R. 1972. The effect of seed size, germination time and sowing density on seedling development in Radiata pine. *Australian Forest Research* **5**(4) : 25-28.

- \*Guha, P.T. 1973. *Populus gamblei*: Little known poplar of eastern Himalayas. *Proceedings of Fruit and Forestry Product Conference*, Dehradun.
- Hare, R.C. 1977. Effect of shoot girdling and season on rooting of slash pine cuttings. US Forestry Service Research Notes, No. 80-202, 3 p.
- Harrington, J.F. 1970. Seed and pollen storage for conservation of plant gene resources. **In** : *Genetic Resources in Plants, their Exploration and Conservation*. Handbook No.11. International Biological Programme, London
- Harrington, J.F. 1972. Seed storage longevity. **In**: *Seed Biology*, vol. 3, pp145- 245.
- Hartman, H.T., Kester, D.E. and Davies, F.T. 1993. *Plant Propagation Principles and Practices*. VI Edition Perentice-Hall of India Pvt. Ltd., New Delhi. 165p.
- Hartman, H.T., Kester, D.E., Davies, F.T. and Geneve, R.L. 1997. *Plant Propagation Principles and Practices*. 6<sup>th</sup> Edn. Prentice-Hall of India Pvt. Ltd., New Delhi. pp 276-328.
- Haissig, B.E. 1971. Influence of IAA on incorporation of <sup>14</sup>C uridine by adventitious root primordial of brittle willow. *Annals of Botany* **132** : 263-267.
- Haissig, B.E. 1974. Metabolism during adventitious root primordium initiation and development. *New Zealand Journal of Forestry Science* **4** : 324-327.

- Haissig, B.E. 1982. Activity of some glycolytic and pentosphosphate pathway enzymes during the development of adventitious roots. *Physiology of Plants* **55** : 261-272.
- Haissig, B.E. 1986. Metabolic process in adventitious rooting of cuttings. **In** : *New Root Formation in Plants and Cuttings* (ed. M.B. Jackson). Martins N. Jhoff Publishers, Boston, 141-189 pp.
- \*Heit, C.E. 1961. Abnormal germination during laboratory testing in coniferous tree seed. *Proceedings Institute Seed Testing Association*. **26**: 419- 427.
- Houseley, S. and Bentley, J.A. 1956. Studies in plant growth hormones. IV. Chromatography of hormones and hormone precursors in cabbage. *Journal of Experimental Botany* **7** : 719.
- Hume, L. 1984. The effect of seed maturity, storage on soil surface and burial on seeds of *Thlaspi arvense* L. *Canadian Journal of Plant Sciences* **64**: 961-969.
- Husen, A. and Mishra, V.K. 2001. Effect of IBA and NAA on vegetative propagation of *Vitex negundo* L. through leafy stem cuttings from hedged shoots during rainy season. *Indian Perfumer* **45**(2): 83-87.
- Husen, A. 2002. Adventitious root formation of shoot cuttings of *Datura innoxia* Mill by IBA under intermitted mist. *Annual Forester* **10**(2): 280-283.
- ISTA, 1993. International rules for seed testing. International seed testing association. Seed science and technology, p.21

- Kapoor, 1991. Forest Resources. **In** : *Agriculture in Jammu and Kashmir : A perspective* (ed. M.A Masoodi) (Mohisan book series, Rawalpura Bypass Chowk, Srinagar) p.53.
- Kral, J. and Sebanek, J. 1983. Effect of auxin growth regulators on adventitious root formation from the basal and apical parts of stem cuttings of common Alder (*Alnus glutinosa* L.). *Acta University Agri. Brno* **31**(1/2) : 5-11.
- Laure, M.V. 1945. Fodder tree in India *Indian Forester Leaflet*, 82, Silviculture, FRI, Dehradun, 17p.
- \*Loach, K. 1988. Hormone application and adventitious root formation on cuttings. *Acta Horticulturae* **226** : 126-132.
- Luna, R.K 1996. Plantation trees, p.126. International Book Distributors, Dehradun.
- Maithani, G.P., Bahuguna, V.K. and Sood, O.P. 1987. Maturity indices and pre-treatment studies on the seeds of *Ficus benjamina*. *Indian Forester* **113**(7) : 6-9.
- Maithani, G.S., Beniwal, B.S. and Pyarelal. 1990. Studies on standardization of nursery technique (Method of seed sowing and optimum irrigation schedule) of *Dalbergia sissoo* Roxb. *Van Vigyan* **28**(3): 94-98.
- \*Maki, T.E. 1940. Significance and applicability of seed maturity indices for Ponderosa pine. *Journal of Forestry* **38** : 55-60.

- Manaco, P.A., Ching, T.M and Ching, K.K. 1980. Rooting of *Alnus rubra* cuttings. *Tree Plantation Notes* **31**(3) :22-24.
- McAlister, D.F. 1943. The effect of maturity on the viability and longevity of the seeds of western range and pasture grasses. *American Society Agronomy Journal* **35**: 442-453.
- \*Mebberley, D.J. 1989. The plant book : A Portable dictionary of the higher plants. Cambridge University Press, Cambridge, New York, New Rochelle, Melbourne, Sydney. 20p.
- Mindawati, M.S and Rohayat, N. 1994. Effect of fruit colour of *Gmelina arborea* on germination and seedling growth. *Bulletin Panelotian Hutan*. **560**: 43-52.
- Misra, K.K. and Jaiswal, H.R. 1993. Effect of size of polythene bags and potting mixture on survival and growth of silver oak. *Indian Forester* **119**(1): 941-943.
- Mughal, A.H. 1996. Studies on container reared and nursery reared seedlings of *Deodar* and *Cupressus*. *Indian Forester* **122**(8) : 760-762.
- Mughal, A.H. and Thapliyal, R.C. 2006. Cone and seed maturity indices in *Cedrus deodara* (D. don, G. don). *Indian Journal of Forestry* **29**(2): 167-174.
- Nanda, K.K. 1970. Investigation on the use of auxin in vegetative reproduction of forest plants. *Final Report PL-480. Research Project*, 125 p.

- Nanda, K.K., Nanda, V.K. and Kumar, P. 1970. Some investigation of auxin effects on rooting of stem cuttings of some forest tree species to auxins. *Indian Forester* **94**: 154-162.
- Nanda, K.K. 1975. Physiology of adventitious root formation. *Indian Journal of Plant Physiology* **18**(1): 80-89.
- \*Noggle, G.R. and Fritz, G.J. 1983. *Introductory Plant Physiology*. Prentice-Hall, India. 70p.
- Oliver, W.W. 1974. Seed maturity in White fir and Red fir. *USDA Forest Series Research Paper PSW* **90** : 1-12.
- \*Ooyamma, N. and Toyoshima, A. 1965. Rooting ability of Pine cuttings and its promotion. *Bulletin of Governmental Forestry Experimentation Station*.
- Pal, M. 1988. Clonal Forestry: a feasible approach for yield improvement in forest plantations. *Annual conference on Silvicultural Research Work of N-W Region*. Held at Nanital (India), Nov. 5-7, 1988.
- Pearson, R.S. and Brown, H.P. 1932. Commercial Timber of India, their distribution, supply, anatomical structure, physical and mechanical properties and uses (Govt. Central Publication Branch, Calcutta.). Vol. 2. Periodical Express, 42-D Vivek, Shahadra, Delhi, India.
- \*Psota, V., Kralik, J., Ondrackora, O. and Sebanek, J. 1986. Effect of cyclophysis of the levels of endogenous gibberellins and selected plant growth regulators on rhizogenenous in common Alder (*Alnus glutinosa* L. Gaerth) . *Acta University Agriculture* **34**(1) : 7-23.

- \*Pukittayacamee, P., Boantawee, P., Waswanid, P. and Banergee, P. 1995. Effect of fruit maturity, depulping techniques and drying conditions on germination of *Azadirachta indica* var *siamensis* seed. *Technical Publication-ASEAN Forest Tree Seed Centre Project* **32** : 11-15.
- Puri, G.S. 1960. Indian Forest Ecology. Oxford Printing Works, New Dehli **1** : 1-318.
- Qaisar, K.N and Mishra, V.K. 2005 Nursery and Field performance of *Acacia catechu* Willd. seedlings raised in different type and size of containers. *Journal of Non-Timber Forest Products* **12**(2): 91-95
- \*Rietveld, W.J. 1978. Forecasting seed crops and determining cone ripeness in South-Western Ponderosa pine, USDA. *Forestry Service General Technical Report, R.M.* **50** : 1-12.
- Rinallo, C.1977. Rhythms of root formation in cuttings of *Alnus Cordata*. *Italia Forestale I Montana* **32**(6) : 254-266.
- Salem, M., Bhardwaj, S.D. and Kaushal, A.N. 1994. Effect of seed weight, nitrogen source and split application on growth of *Celtis australis*. *Indian Forester* **120**(3) : 236-241.
- Saul, G.H. and Zsuffa, L. 1982. Vegetative propagation of alder (*Alnus glutinosa* L.) by rooted cuttings. *Forest Research Note, Ontario* **33** : 3.
- Schopmeyer, C.S. 1974. Seeds of woody plants in the United States. Agriculture Handbook 450 USDA Forestry Service, Washington, DC.

- Sen, P.K., Basu, R.N., Bose, T.K. and Chaudhury, R.N. 1967. Mist propagation of difficult to root fruit tree cuttings. *Conference of Tropical Forestry Propagation Far East*, New Delhi, 9-12 December, item No. 6.
- Singh, A. 2006. Status and propagation of Hackberry *Celtis* spp. A multipurpose tree species of Kashmir valley. M.Sc thesis submitted to Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, pp. 37-42.
- Singh, O. 1998. Seed maturity indices in Silver fir (*Abies pindrow* Spach.). *Indian Forester* **124**(3): 243-246
- Singh, O. and Kachari, J. 2006. Seed maturity indices in Khasi Pine (*Pinus kesiya*). *Indian Forester* **132**(12): 1689-1691
- Singh, S.M. and Kumar, H. 1974. Influence of ringing a source shoot and concentration of IBA on the performance of *Grewia asiatica* stem cuttings. *Indian Journal of Agriculture Science* **37**(3) : 151-154.
- Singh, V. 1989. Seed maturity indices in Spruce. *India Forester* **115**(5): 342-347.
- Sorensen, F.C. and Cambell, R.K. 1993. Seed weight, seedling size correlation in coastal Douglas fir, genetic and environmental components. *Canadian Journal of Forestry Research* **23**(2) : 275-285.
- Stein, W.I., Slabaugh, P.E. and Plummer, A.P. 1974. Harvest processing and storage of fruits and seeds. **In** : *Seed of Woody Plants in United*

*States*. Agricultural Handbook No. 450. USDA. Forest Service, Washington. DC. USA. pp 300-320.

Stoeckler, J.H. and Slabaugh, P.E. 1965. Conifer nursery practice in the Prairie-plains. *US Department of Agriculture Handbook* **278** : 93.

\*Suchbest, G.H. 1956. Effect of ripeness on viability of sugar, jeffrey and ponderosa pine seed. *Proceedings Society of American Forest* **1955** : 67-69.

Sutherland, D.C. and Day, R.J. 1988. Container volume effect survival and growth of white spruce, black spruce and Jack pine, seedlings. A literature review. *North Journal Applied Forest* **5**: 185-189.

Thakur, I.K. and Gupta, R.1998. Effect of auxins on rooting of *Alnus nitida* Endl. Cuttings. *Indian Journal of Forestry* **21**(2) :174-175.

Thakur, I.K. 1999. Studies on the effect of seasons and auxins concentration on rooting and sprouting of *Alnus nitida* Endl. Stem cuttings. *Indian Journal of Forestry* **22**(3) : 194-196.

Thakur, A., Chowhaan, P.H., Khobragade, N.D. and Sharma, P. 2000. Study on effect of time of seed collection on germination of *Dipterocarpus retusus* BL. Syn. D.I. *Macrocarpus vesque* **126**(8) : 799-800.

Thakur, I.K. and Pant, K.S. 2002. Vegetative propagation of *Alnus nitida*. *Bionotes* **4**(3):70.

- Thapliyal, R.C. and Rawat, M.M.S. 1991. Studies in the germination and viability of seed of two species of Himalayan Alder, *Alnus nitida* and *A. nepalensis*. *Indian Forester* **117**(3) : 256-261.
- Tripathi, R.S. and Khan, M.L. 1990. Effect of seed weight and microsite characteristics on germination and seedling fitness in two species of *Quercus* in a sub-tropical wet hill forest. *Oikos* **57** : 289-296.
- Troup, R.S. 1921. *Silviculture of Indian Trees*. Cleredon Press Oxford. **3** :193.
- \*Upadhayay, L., Singh, R.P., Tewari, A., Bisht, S. and Shah, S. 2006. Seed maturation indicators in *Bauhinia retusa* Ham. in Kumaun central Himalayas. *Indian Journal of Forestry* **29**(4) : 367-371.
- Venkatesh, A., Vanangamudi, K and Umarani, R. 2002. Effect of container size on seedling growth of *Acacia nilotica* subsp. *Indica*. *Indian Forester* **128**(7): 795-799.
- \*Veracion, V. and Padolina, C.B. 1971. Cone maturity as a variable to germination of Benguet pine (*Pinus insularis* Endl.) seeds. *Occasional Paper Bureau Forests, Philippines* **41** : 1-9.
- Vimal, O.P. and Tyagi, I.J. 1984. *Energy from biomass*. Prentice Publishing Co. 139-147.
- Willan, R.L. 1985. *A guide to forest seed handling with special reference to the tropics*. FAO Forestry Paper, 20/2, FAO, Rome.

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\* Original not seen

**APPENDIX-I****Villages surveyed throughout the Kashmir valley to arrive at the status of Western Himalayan Alder tree**

<b>District</b>	<b>Block</b>	<b>Panchayat</b>	<b>Village</b>		
1. Srinagar	i. Srinagar	Dara	New Theed Syedpora		
		Burzahama	Burzahama Wanihama		
		Batapora	Batapora-A Syedpora Hamchi		
		2. Ganderbal	i. Ganderbal	Nunar	Nuner Proper Dadkanth
				Tulmulla	Tulmulla Proper Dangerpora
2. Ganderbal	i. Ganderbal	Ganderbal	Doderhama Saloor		
		Warpuh	Warpuh Shuhama		
		ii. Lar	Lar	Lar Proper Khranihama	
	Manigam		Manigam Wayol		
	Dub		Dub		
	Haripora		Haripora Bonetul		
	iii. Kangan	Kangan	Kangan Margund		
		Wangat	Wangat Pahalnar		
		Wusan	Wusan Preng		
		Sonamarg	Sonamarg Sarbal		

	iv. Wakura	Barsoo	Barsoo Wandhama
		Gogigund	Gogigund Mujigund
		Batweena	Batweena Payeen Batweena Balla
		Dab	Dab Shadipora
3. Budgam	i. B.K. Pora	B.K. Pora	B.K. Pora Nowgam
		Chattergam	Chattergam Wagura
		Dawlatpora	Dawlatpora Punzipora
		Wathora	Gopalpora Bugam
	ii. Chadura	Chadura	Chadura Alipora
		Hanjoora	Hanjoora Rangar
		Sogam	Sogam Gund
		Namtihal	Namtihal Yaarkalan
	iii. Khansahib	Arigam	Arigam Doodpathri
		Raithan	Raithan Narkara
		Watterhel	Waterhel Brail
		Rawalpora	Rawalpora Khospora

	iv. Nagam	Nagam	Nagam Tangnaar
		Nowpora	Nowpora
		Badipora	Lolipora Badipora
		Harfobatpora	Buzgoo Harfobatpora
			Narpورا
4. Anantnag	i. Qazigund	Konigam	Watihal Chakbarwani
		Panzath	Wanpora Shampora
		Lowr Munda	Badarmun Chang
		Sadowara	Khatgund Kralpora
	ii. Qamoh	Rewani	Hovar Mushkooor
		Kujar	Tanjbal Talgranth
		Frisal	Shorpora Badura
		Arwani	Kherpora Nowpora
	iii. Shahabad	Browgam	Mohamudabad Bunpora
		Kredimowpora	Kredi (A) Nowpora
		Verinag	Gurnar Malikpur
		Larkipora	Naidpora Larkipora

	iv. Achabal	Brantr-Darpora	Branti Palpora
		Achabal	Chaki-achabal Jagigund
		Shalipora	Shalipora Chek
		Trahpu	Sunsun Magraypora
5. Pulwama	i. Kakapora	Newa	Newa Zadoora
		Pinglon	Pinglon Pathan
		Lajoora	Lajoora Kail
		Kakapora	Kakapora Badipora
	ii. Keller	Rajpora	Rajpora Chandpora
		Rahmoo	Rahmoo Zaajigam
		Drubgam	Drubgam Kespur
		Zawoora	Zawoora Nagbal
	iii. Pulwama	Tahab	Tahab Malapora
		Achan	Achan Patipora
		Malangpora	Malangpora Bandarpora
		Chandagam	Chandagam Mooninabad

	iv. Pampore	Andrusoo	Andrusoo
		Barsoo	Barsoo
		Hatinwara	Hatinwara
		Hunipora	Hunipora
6. Shopian	i. Shopian	Heff	Heff
			Shirmal
		Momander	Momander
			Chandpora
		Pinjoora	Pinjoora
			Gughad
		Saidpora	Saidpora
			Amshipora
7. Kulgam	i. D.H. Pora	D.H. Pora	Ahmadabad-A
			Ahmadabad-B
		Boh	Boh-A
			Boh-B
		Chimmer	Chimmer-A
			Chimmer-B
		Asnoor	Asnoor
	ii. Kulgam	Checkpora	Checkpora
			Ban
		Yaripora	Yaripora
			Humbadau
		Bongam	Bongam-A
			Gania Mohalla
		Chellan	Chehllan
			Pranhal
	iii. Pahloo	Akhal	Akhal
		Asthal	Asthal
		Banmulla	Banmulla
		Brinal	Brinal

8. Bandipora	i. Bandipora	Aloosa	Aloosa
			Malangam
		Quilmuqam	Quilmuqam
			Kema
		Astingo	Astingo
	ii. Gurez	Bankot	Bankot
			Chitternar
		Wanpora	Wanpora
			Badwan
		Khaniyal	Khaniyal
			Faqirpur
		Ismarg	Ismarg
			Gulshanabad
		Kanzalwan	Kanzalwan
			Nayal
	iii. Hajan	Madwan	Madwan
			Breng
		Banyari	Banyari
			Mukhdoomyari
		Shahgund	Shahgund
		Vijpur	
iv. Sumbal	Safapur	Safapur	
		Gratibal	
	Chachihagur	Chachihagur	
		Markand	
	Kakapora	Kakapora	
		Saderkoot Bala	
	Nowbagh	Nowbagh	
		Satkree	
Naidkhai	Naidkhai		
	Asham		

9. Baramulla	i. Baramulla	Baramulla	Bose
			Binner
		Uri	Uri
			Lagama
		Gulmarg	Gulmarg
		Khelanmarg	
		Rohama	Rohama
			Shalkote
	ii. Zainageer	Watlab	Watlab
			Magraypora
		Dangerpora	Dangerpora
			Dooru
		Bomai	Bomai
			Logeripora
		Seelo	Seelo
	iii. Tangmarg	Hajibal	Bohripora
			Alapather
			Babareshi
		Hadrumadan	Madan
			Batipora
Ferozpur		Ferozpur	
	Mahnin		
	Hatipora	Qazipora	
		Wanganpur	
iv. Pattan	Pattan	Pattan	
		Zangam	
	Shirpur	Mirpur	
		Haritrat	
	Nolur	Nolur	
		Sheerabad	
	Wanigam	Wanigam	
		Telgam	

10. Kupwara	i. Kralpora	Kralpora	Idgah	
			Takipora	
		Dardpora	Mukam	
			Thandipora	
		Sheelur	Muslimpora	
			Gofbal	
		Darhari	Darhari	
			Warpora	
		ii. Trehgam	Guglosa	Lonepora
				Bonpora
	Gulgam		Gulgam	
			Batargam	
	Harrai		Qadrabad	
			Kawari	
	iii. Sogam	Trehgam	Sheikhpora	
			Malikpora	
		Sogam	Sogam	
			Wanipora	
		Khumriyal	Khumriyal	
			Tenjbai	
Kanthipora		Kanthipora		
iv. Kupwara	Darpora	Surigam		
		Darpora		
		Lalpora		
	Kupwara	Kupwara		
		Dudwan		
	Drugmulla	Drugmulla		
		Bumhama		
	Mugalpora	Mugalpora		
	Punima			
	Haihama			
	Manzar			

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**Sher-e-Kashmir**  
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**Certificate**

Certified that all the corrections/amendments as suggested by External Examiner Dr. Avtar Singh, Senior Silviculturist-cum-Head, Department of Forestry, Punjab Agricultural University, Ludhiana during Viva-Voce examination held on 28.12.2010 have been incorporated in the manuscript entitled “**Status and Propagation of Alder (*Alnus* spp.) Tree in Kashmir Valley**” submitted by **Mr. Arshad Ahmad Lala (Regd. No. 2006-For-17-M)**.

*Chairman*  
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