Status and Propagation of Indian Bean Tree (*Catalpa bignonioides* Walt.) in Kashmir Valley

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2011

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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

2011

"Parents"

Someone who holds us in arms as we enter this world

Someone who encourages all our efforts and appreciate us wholeheartedly

Someone who listens patiently to our never ending doubts

Some who's eyes shine with pride and happiness at our every little achievement

Someone who helps us to smile instead shedding a tear

Someone who is our life-long friend

DEDICATE MY THESIS

"To serve whom was my dream and

Dream of serving him remain forever"

"MY BELOVED FATHER"

And

"The light which lit up every nook and corner of my life"

"MY SWEETEST MOTHER"

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

This is to certify that the thesis entitled **"Status and Propagation of Indian Bean Tree (*Catalpa bignonioides* Walt.) 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-Kahsmir University of Agricultural Sciences and Technology of Kashmir, is a record of bonafide research work carried out by **Mr. Rafiq Ahmad Mir (Regd. No. 2009-For-26-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. Rafiq Ahmad Mir (Regd. No. 2009-For-26-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 Indian Bean Tree (*Catalpa bignonioides* Walt.) 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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This is to certify that the thesis entitled, **"Status and Propagation of Indian Bean Tree (*Catalpa bignonioides* Walt.) in Kashmir Valley"** submitted by **Mr. Rafiq Ahmad Mir (Regd. No. 2009-For-26-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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Title of the Thesis : **"Status and Propagation of Indian Bean Tree (*Catalpa bignonioides* Walt.) in Kashmir Valley"**

ABSTRACT

Indian bean tree (*Catalpa bignonioides* Walt.) belonging to family bignoniaceae is an exotic tree and has been recently introduced in Kashmir Valley. No information was available with respect to its status and propagation under temperate conditions of Kashmir. To apprise its status and address propagation under Kashmir valley, a project entitled "Status and propagation of Indian Bean tree (*Catalpa bignonioides* Walt.) in Kashmir valley was carried out in the Faculty of Forestry, SKUAST-K, Shalimar during the year 2010-2011.

Detailed survey revealed that farmers do not cultivate the tree species due to lack of knowledge about it as it is recently introduced in valley. Tree species was found growing in low lying aesthetic and recreational sites like roads, parks, gardens and in premises of government offices. Oldest tree was found growing in Cafeteria park, Achabal (Anantnag). Maximum number of trees were found in district Srinager. Studies were also undertaken regarding maturity indices and it was observed that seeds are mature enough by mid of November and seed colour changes from green to silver grey and maximum germination was recorded on mid-November (89.40%). Seed germination increases to 92.07% when seeds were soaked in cold water for few minutes. The seeds germinate within a weeks time

thereby depicting that seeds of *Catalpa bignonioides*) does not possess any kind of dormancy.

Studies conducted on raising of seedling nursery of Indian Bean tree (*Catalpa bignonioides* Walt.) revealed that seedling raised in root trainer 300 cc capacity shows better results in terms of germination (94.63%), survival (85.37%) whereas rest of parameters *viz.* shoot height (27.08 cm), root length (22.75 cm), collar diameter (4.36 mm) and root: shoot ratio (0.58) were highest in polybag of 5″ × 7" size. Studies on vegetative propagation of Indian Bean tree (*Catalpa bignonioides* Walt.) through semi-hardwood cuttings treated with six different concentrations of IBA shows that maximum growth in all parameters was found in case of 4000ppm IBA and was significantly different from control (distilled water).

Key words : Status, nursery raising, vegetative propagation, dormancy, *Catalpa bignonioides* Walt.

Signature of Student Signature of Major Advisor

Dated : _____ 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 express with deep sense of gratitude and indebtedness, my Sincere thanks to My Worthy Chairman of Advisory Committee- Dr. P.A. Sofi, Assistant Professor, Faculty of Forestry, Wadura, Sopore, SKUAST-K for his regular guidance, self and deep interest and incessant encouragement during the entire course of work.

I express my deep heartful thanks to Dr. P.A. Khan (Co-Advisor) Associate Professor, Faculty of Forestry, SKUAST-K, Shalimar; Dr. M.Y. Bhat, Associate Professor, Division of Fruit Science, SKUAST-K, Shalimar; Dr. Tariq Ahmed Raja, Assistant Professor, Division of Agri-statistics, SKUAST-K, Shalimar; Dr. F.A. Banday (Dean PG Nominee), Associate Director (Extension Education) Directorate of Extension Education, SKUAST-K, Shalimar.

I rejoice to express with deep sense of gravitated indebtedness, since thanks to Dr. N.A. Masoodi, Deam Faculty of Forestry SKUAST-K, Shalimar whose cooperation, guidance, encouragement and supervision help me to bring this manuscript out.

I express my sincere thanks to Staff member of Division of Statistics, Staff member of Directorate of Resident Institutions and Staff member of the central Library for their help to accomplish this task.

Rejoice my heartiest appreciation for my guidance, valuable suggestions and cooperation during my study farm faculty members of Faculty of Forestry particularly Dr. K.N. Qaisar, Dr. Parveez, A. Khan, Dr. Vaishnu Dutt, Dr. R. Banyal, Dr. S.A. Gangoo, Dr. Tariq Ahmad Masoodi;

I express deep respect to non teachings staff of Faculty of Forestry for their timely cooperation to Mr. Manzoor A. Rather, Mr. Manzoor A.

Bhat, Mr. Tariq A. Rather, Mr. Ishfan Ahmed, Mr. Gh. Mohi-ud-din, Mr. Basharat Mir. Mehraj-ud-din and other field staff of my faculty.

It is the important to mention here that my project would not have been accomplished without my Batch mates, Seniors and Friends- Mr. Altaf Ganie, Mr. Javaid Iqbal, Mr. Sohail A. Wagay, Mr. Parveez. A. Parrey, Mr. Imtiyaz A. Wani, Mr. Touseef Bhat, Mr. Hilal Ahmed Bhat, Mr. Hilal A. Rather, Mr. Mumtaz Majeed, Mr. Amanjeet Singh, Mr. Fayaz A. Shiekhm, Mr. Mohd. Afzal Malla, Iqbal Jeelani, Mr. A. Dar and Mr. Fazil Rasool Mir, Mr. Mohd. Younis Mir. For there constant support, help and encouragement.

I am deeply indebted to my parents and other family members particularly to my brother Mr. Mohammad Yousuf Mir whose moral, monetary support and encouragement help me to accomplish this task.

I express deep indebtedness and sincere thanks to all those who help accomplish me to bring this manuscript may not have got a mention , but all will remain in my heart.

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.

Rafiq Ahmad Mir

Place : Shalimar, Srinagar

Dated :

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CHAPTER – 1

INTRODUCTION

Forests are renewable resources; occupy a place of considerable importance in our socio-economic development and are more popularly known as green gold. Forests are type of biological community dominated by trees and other woody vegetation. The phenomenal pressure of population, urbanization and industrialization has resulted in over exploitation of natural forests, reducing the forest cover of India from about 40 to 21 per cent to its geographical area as against 33 per cent required under National Forest Policy 1988. Forests perform various types of functions. They modify local climate, control soil erosion, regulate stream flow, support a variety of industries, provide livelihood for many communities and offer opportunities for recreation. They reduce wind force and influence air temperature. They add the forest floor large quantities of leaves, twigs and branches which, after decomposition, form humus. They provide industrial wood, timber, fuel wood, fodder and several other minor products of great economic value. They provide natural environment for wildlife.

Jammu and Kashmir state is called paradise on earth. The state has distinct agro-climatic zones comprising subtropical, tropical, temperate and cold zone resulting in rich variety of forests. Total geographic area of Jammu and Kashmir is 2,22,236 sq km with forests occupying 20230 sq km amounting to 19 per cent of total geographic area of state (Anonymous, 2010). In Kashmir valley area under forests is 8,128 sq km (50.97%) and in Jammu and Ladakh area under forests is 12,066 sq km (45.89%) and 36 sq km (0.05%), respectively (Anonymous, 2010). Coniferous forests occupying 40 per cent of total growing stock and 9.32 per cent is occupied by broad leaved forests. Nature has bestowed the valley with large number of tree spp., shrubs, herbs etc. Among the tree species, few are used for ornamental purposes. Some of these are *Cupressus torulosa*, *Cedrus deodara*, *Juniper* spp., *Albizia* spp., *Acer* spp., *Aesculus indica*

and *Populus* spp., *Salix* spp., *Quercus* spp., *Platinus* spp., *Paulowinia fortunei*, *Catalpa bignonioides*. These tree species have got immense importance in enhancing the Aesthetic and recreational value of public parks, private parks, roads, kitchen gardens etc.

With the ever-increasing population of state, forests have been placed under tremendous pressure arising out of increasing demand for fuel wood, fodder, timber and other forests products. This has resulted in acute degradation of forest resources. The issue, therefore, is to arrest the degradation of forests resources to maintain ecological balance and simultaneously meet the challenges of increasing demand of forests products and unemployment. Raising of seedling of tree species having aesthetic and recreational value and their marketing will improve the income of forest department besides providing employment to large number of youths of valley and ameliorating the environmental conditions. It also reduces gap between demand and supply of small timber, fodder and fuelwoods etc.

Catalpa bignonioides Walter is species of catalpa belonging to family bignoniaceae (Order lamales) is native tree of southern U.S. in Albama, Florida, Georgia, Lousiana, Mississippi, commonly called southern catalpa, Indian bean tree and cigar tree. Catalpa is unconditionally a southern tree, European first observed the tree growing in fields of Chewkar native American tribes, who called it catalpa. However, its vitality enables it to flourish in north as well.

Indian bean tree is among ornamental tree, adapted to sandy, loamy, clay soils, prefers acidic, neutral and alkaline soils, requires moist soils (Chittendon, 1951 and Bean, 1981).

Catalpa bignonioides Walter is a medium sizes tree 9 to 18 m tall (Little *et al.*, 1962) with trunk upto 1 meter diameter with brown to grey bark, short trunk supports long strangling branches which form broad and irregular head. The roots are fabulous and brittle.

Catalpa is widely grown as ornamental tree (Chittendon, 1951) having distinction of being some of showiest flowers of all the American native tree, thus holding associate place in parks, gardens and roads of all temperate countries. Its bark has antiseptic properties, antidote to snake bites, sedative and vermifuge properties. Plant is also used for whooping cough. Bark is used as substitute for Quanine. Due to extensive root system it has been planted in lands that subjected to landslides to stabilize soil. Wood is used for fence posts and in rail road ties (Chiej, 1984; Usher, 1974; Sergent, 1965 and Vines, 1982).

Raising of seedling nursery of any species is successful only when mature and viable seeds are collected. The knowledge of exact stage of collection is of immense importance to avoid collection of immature and non-viable seed (Willians, 1985) which results in large wastages of money and labour. Literature scanned doesnot show much work on propagation either by seed or cutting. Through mass propagation of seeds of catalpa is an easy and cheap method requiring no stratification and scarification to release dormancy. Germination in excess of 90 per cent has been obtained in about 12 days with good quality seeds of southern and northern catalpa (Boner and Graney, 1974). Francis (1993) reported 40 per cent germination of *Haitin catalpa* in 8 days on pottery mixture. Cutting treated with growth hormones have chances of survival.

Despite being tree of tremendous aesthetic, recreational value and also being an exotic in nature there is lack of general information regarding its propagation, concentration and distribution in Kashmir valley. In view of promising potential of tree and problems related to its propagation programmes, a project entitled "Status and Propagation of Indian Bean Tree (*Catalpa bignonioides*) in Kashmir Valley" was undertaken with following objectives :

- To study status of *Catalpa bignonioides* in Kashmir
- Nursery raising through 1) Seeds 2) Cuttings

CHAPTER – 2

REVIEW OF LITERATURE

2.1 Description of the tree

Catalpa bignonioides is a medium sized deciduous tree growing 9 to 18 meters tall (Little *et al.*, 1962; Sergent, 1965) with a trunk upto 1 meters diameter with brown to grey bark, maturing into hard plates or ridges. The short thick trunk supports long and straggling branches which form a broad and irregular head. The roots are fibrous and brittle. Its juice is watery and bitter (Keeler, 1900). The leaves are large and heart shaped, being 20 to 30 cm long and 15 to 20 cm broad. The bright green leaves appear late and as they are full grown before the flower clusters open, and much to beauty of blossoming tree. Flowers are 2.5 to 4 cm across, trumpet shaped, white with yellow spots inside, they grow in panicles of 2 to 40. In the northern states it is late bloomer, putting forth great panicles of white flowers in the last weak of June or early July when the flowers of other trees have mostly faded. The fruit is long, thin bean like pod 20 to 40 cm long and 8 to 10 mm diameter; often stays attached to tree during winter. The pod contains numerous flat light brown or silvery grey seeds with two papery wings. Bark is light brown tinged with red. Branchlets farming regularly by pairs, at first green, shade with purple and slightly hairy, later gray or yellowish brown, finally reddish brown.

2.2 Species and distribution

Catalpa bignonoides Walter is species of catalpa belonging to family bignoniaiceae (Order lamiales) is native tree of southern U.S.A. in Alubama, Florida, Georgia, Lousiana, Mississippi, commonly called southern catalpa.

Catalpa is unconditionally a southern tree. European first observed the tree growing in fields of Cheroker native American tribes, who called it catalpa.

However, its vitality enables it to flourish in north as well, and accordingly its natively is somewhat in doubt (Keelar *et al.*, 1900).

2.3 Utilization

Catalpa is widely grown as ornamental tree (Chittendon, 1956) having distinction of being some of showiest flowers of all American native trees, thus holding an associated place in parks and gardens of all temperate countries. Its bark has antiseptic properties, antidote to snake bites and sedative vermifuge. Plant is also used against whooping cough. Bark is used as substitute for quinine. Due to extensive root system it has been planted in lands that are subjected to landslips to stabilize soil. Wood is used for fence posts and in rail road ties (Chiej, 1984; Usher, 1974; Sergent, 1965; Vines, 1982).

2.4 Maturity indices

The literature scanned does not show much work on propagation of Indian bean tree (*Catalpa bignonioides*) nor much information is available on catalpa seed and its collection. Where as maturity indices studies are very important and has been conducted in other species. The knowledge of exact stage and time of seed maturity is essential for collection of abundant quality of healthy and vigorous seed (Troup, 1921). Besides, seed collection 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, deformed seedlings (Heit, 1961; Suchbest, 1956). Reproduction development of plant brings with formation of flower beds and progress through anthesis, fruit development and accumulation of storage materials in the seed and buds with physiologically maturity, when seed reach its maximum dry weight (Tekrony and Egli, 1977). Maturity may be reached several weeks earlier on hill tops than in nearby valleys (Cobb, 1959). Thus fruit collection should be started only when seeds are sufficiently mature. Therefore, indicators of maturity for individual species is a must, so that collections is made right in time, otherwise immature

collection of seeds will result in loss of time, money and failure of plantations. Similarly collection after dispersal is difficult and it is time consuming and not much seeds can be collected from mother trees.

2.4.1 Maturity indices and colour

The seeds of *Catalpa bignonioides* are small and light so need to be collected when they are sufficiently mature. If allowed to ripe fully these may be carried away by winds. Colour change in fruit provides a simple and reliable criteria for judging seed maturity (Willan, 1985). The change in pod colour from green to dark red and seed colour from green to whitish brown is a useful indication of maturity in case of *Bauhinia retusa* Ham (Upadhaya *et al.*, 2006). The change in fruit colour is the best available criteria for judging the maturation of seeds as shown in *Carrissa opaca* and *Ficus benjamina* (Maithani *et al.*, 1990). Bonner (1972) established relationship between colour change in fruits/seeds and maturation time.

2.4.2 Maturity indices and seed weight

The most generally accepted criteria means of maturity is when the seeds have reaches its maximum dry weight a point called physiological maturity (Harrington, 1972). Seed weight is positively correlated with seedling vigour in some tree species (Quraishi *et al.*, 1996). Nizam and Hussain (1999) reported that effect of seed weight of *Albizia saman* on seed germination and initial seedling grown in nursery conditions. Seed germination per cent, growth of seedling and their fresh and dry weight increased with the increase in seed weight.

2.4.3 Maturity indices and specific gravity

Specific gravity is one of the important criteria in judging maturity of the seed. The relationship between declining specific gravity and increased germination has been reported by a number of workers on various trees (Maki, 1940; Fowells, 1949; Cram, 1956; Oliver, 1974). Specific gravity of mature cones of spruce varies from 0.97 to 0.99 (Singh, 1989). In case of silver fir, specific

gravity of mature cones varied from 0.97 to 0.98 and germination per cent of the seeds collected from such cones was about 32 per cent (Singh, 1998).

Laboratory studies were conducted to determine a suitable method for classifying seeds based on the specific gravity and seed weight and examine the effect of seed weight and specific gravity on germination of Touki (*Angelica acutiloba*) seeds and seedlings emergence and growth. The result showed that by increasing the seed weight, the germination percentage increased and seedling growth was promoted (Ninh *et al.*, 2006).

Specific gravity of *Cedrus deodara* cones was reported to be 0.78 in north Kashmir and 0.98 in south Kashmir at maturity (Mughal and Thapliyal, 2006).

2.4.4 Maturity indices and moisture per cent

Maturity is closely related to decline in moisture per cent of seed (Adams and Rinnie, 1981; Pandit *et al.*, 2002). In case of *Abies pindrow*, the germination and moisture content were found correlated (Singh, 1998) complete desiccation is injurious to most seeds and degree of drying can be injurious was shown by Barton (1935). Moisture content of 4 to 8 per cent is considered safe for long term storage for genetic conservation (IBPGR, 1976). Singh and Kachari (2006) reported that germination per cent of seeds increases with decreasing specific gravity and moisture content in cones of *Pinus kesiya* (Khasi pine).

2.4.5 Maturity indices and germination

Temperature is most important environmental factor that regulates the time of germination partly due to climatic adaptation (Hartman *et al.*, 1990). Germination rate has been low at low temperature but increases gradually as temperature rises (Koller, 1972). In Hoolong (*Dipterocarpus retusus*), seeds collected during first half of March showed maximum germination percentage (Thakur *et al.*, 2000). The medium sized seeds of *Quercus leucotricophora* (Ban oak) excelled over the other seed grades with respect to all the germinability attributes, irrespective of experimental conditions (Gautam and Bhardwaj, 2001).

Singh and Kachari (2006) reported that germination percentage of seeds increased with decrease in specific gravity and moisture content in cones of *Pinus kesiya* (Khasi pine). In *Celtis australis* (Hackberry tree) germination percentage increases from 0 to 23 per cent as specific gravity decreases from 1.22-1.03 per cent, respectively (Singh, 2006). Again it was observed that germination percentage increases from 0-23 per cent as moisture content reduced from 52.19 to 31.69 per cent, respectively in case of *Celtis australis* (Singh, 2006).

2.5 Dormancy

Seeds in many species fail to germinate inspite of presence of favourable environmental conditions. Janick (1974) termed this as seed dormancy. Seed dormancy has been attributed to one or more of following reasons (Barton, 1965; Lang, 1965 and Stockes, 1965) :

- Hard and impermeable seed coats
- Immaturity of embryo
- After ripening in dry storage
- Light sensitivity of seed

Donelly (1970) reported that besides environmental factors, genetic components of the species also induce dormancy. Flint and McAlister (1937), Barton (1965), Brant *et al.* (1971) and Villiers (1974) have reviewed the above factors from time to time. Some seeds which exhibit little or no dormancy deteriorate rapidly on storage (Osborne, 1977). Hartmann and Kester (1976) reported that purpose of soaking seeds in water is to modify hard seed coat, remove inhibition, soften seed coat and reduce the time of germination of seeds of *Cassia fistula* (Amaltas). Seeds of *Ulmus wallichiana* (elm) are not having any kind of dormancy as reported by Bhat *et al.* (2007).

2.6 Propagation by seeds

Successful regeneration of any species depend on its seed quality and quantity. Germination of seeds is the initial and under same circumstances critical step in afforestation by natural or artificial means. Seeds of different species and same species from different provenances behave differently in their germination response and knowledge of same is very essential for understanding plantation programmes. Method of raising seedlings have a profound influence on morphometric parameters of seedlings viz., seedling weight, shoot collar diameter and total dry weight throughout the growth period of seedling. For under studying of any plantation programmes there should be enough knowledge of raising seedling by various methods viz., open bed, polybag and root trainers.

Comparative study on the quality of bamboo seedlings raised in root trainer and polybags kept on iron bed revealed that seedlings raised in 300 cc root trainer showed better quality parameters compared to almost same sized polythene bag (Gera *et al.*, 2007). Luna and Chamoli (2006) concluded that 300 cc root trainers and 5 months gestation period produced maximum biomass compared to 200 cc and 150 cc containers among *Albizia procera, Eculyptus tereticornis* and *Acacia catechu* seedlings. Biomass parameters increased with increase in container size and were maximum in polybags. However, biomass parameters were highest in Hiko tray raised *Pinus roxburghi* plants (Kumar *et al.*, 2005). Qaiser and Mishra (2005) studied the nursery performance of *Acacia catechu* seedlings raised in different type and size of containers. The bottom perforated polybags and root trainers raised seedlings depicted better values of seedling quality parameters viz. sturdiness, root/shoot ratio and Dickson quality index, which indicated the overall quality of seedlings. Sutherland and Day (1998) reported increase seedling growth with increase in volume of containers. Maithani *et al.* (1990) studied on standardization of nursery technique viz., methods of seed sowing, optimizes irrigation schedule of *D. sissoo* and concluded that line sowing

method with twice a day irrigation (Morning and evening) enhance germination of seed and resulted in better survival.

Hellum (1978) and Preising *et al.* (1979) reported that root system of both containerized seedling bear rootstock differ substantially from those of naturally regenerated seedlings in spruce and dauglas fir, respectively. Endean and Carlson (1975) reported that increasing the container size resulted in better growth in seedling of *Pinus contorta*. Misra and Jaiswal (1993) reported that in silver oak maximum survival, collar diameter, plant height in bigger size of polybags. Mughal (1996) reported that *Cupressus torulsoa* and *Cedrus deodara* attain optimum shoot or root development when grown in open nursery beds. Shrivastava *et al.* (1998) showed potting mixture of compost:sand:soil in ratio of 2:1:2 best for raising seedlings of Eculyptus hybrid. Bonner and Graney (1974) obtained germination in excess of 90 per cent (25 + samples) in about 12 days with good quality seeds of southern and northern catalpa. They also recommended pine needle mulch for southern catalpa. Willian and Hanks (1990) recommended bud density of 108 to 215 seedlings/meter square in catalpa species.

2.7 Vegetative propagation

Vegetative or asexual propagation is used to produce a plant identical in genotype with the mother plant. It is most convenient, easiest and economical method of propagation for some important crops (Hartman *et al.*, 1993). Vegetative propagation offers the advantage of genetic uniformity and immediate availability of the superior individuals for producing individuals of desired character, provides an opportunity to harness and exploit genetic variation directly (Zobel and Talbert, 1984). The literature scanned reveals that not much work has been done to propagate catalpa through cuttings.

Mumtaz *et al.* (2009) studied the vegetative propagation of *Aesculus indica* through stem cuttings treated with different concentration of IBA. The study revealed that cuttings treated with 4000 ppm IBA showed beter performance

in terms of sprouting and rooting percentage. The highest rooting of (75%) was found in cuttings treated with 4000 ppm IBA which was significantly higher than other concentrations. Siddiqui and Hussain (2007) studied the effect of different concentrations of IBA on *Fiscus Hawaii* cuttings on softwood, semi-hardwood and hardwood cuttings i.e. 1000, 2000, 3000, 4000, 5000 and 0 ppm at Agricultural Research Institute, Tarnab, Peshawar, Pakistan concluded that maximum sprouting, leaves per plant, plant height, shoots per plant, leaf area, shoot thickness, root length and roots per plant was recorded in cuttings treated with 4000 ppm IBA as compared to least in control. Lisowska and Wysokinska (2000) studied *in vitro* propagation of *Catalpa ovata* from shut tips and nodal explants as well as from cotyledon derived calluses. They used by Schenk and Helderbrandt (1972) or Lioyd and Mccown (1980) basal media, supplemented with 6-benzyleadenine (2.2-22.2 micromoler) alone or in combination with Indole 3-acetic acid (0.6 micromoler). Baul *et al.* (2008) studied effect of different hormones on root cuttings of *Stereospermum suaveolens* DC, growth. Rooting efficiencies of cuttings derived from selected mature mother trees were studied using four different concentrations of Indole-3-butric acid (IBA) viz. 0, 0.1, 0.2 and 0.4 per cent IBA applied at 40 microgram/cutting (0.4% concentration) resulting in significantly higher rooting response compared to control. Longest roots and higher survival of roots was obtained in case of 0.2% IBA. Sagwal (1989) studied the optimum size of root cutting length for propagation of *Ribinia pseudoacacia*. In the root length study, root length of 30 cm was reported as optimum size. The survival rate exhibited by plants having 30 cm root length was 100 per cent.

The review of literature scanned indicated that very less information is available on propagation of *Catalpa bignonioides*. Therefore, an attempt has been made to collect the relevant information under the title “Status and propagation of Indian bean tree (*Catalpa bignonioides*) in Kashmir valley”.

CHAPTER – 3

MATERIALS AND METHODS

The research problem entitled "Status and Propagation of Indian Bean Tree (*Catalpa bignonioides*) in Kashmir Valley" was conducted in the Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar during the year 2010-2011. A detailed account of techniques followed and materials used during the conduct of research work is presented below :

3.1 Experimental site – location, physiography and climate

The state of Jammu and Kashmir is strategically located in north-west corner of India. It shares its border with China in east, Pakistan in west, Afghanistan and Russia in north and plains of Punjab and Himachal in south and southeast. The state of Jammu and Kashmir stretches between 32^{o}-17′ to 73^{o}-35′ north latitude and 72^{o}-31′ E to 80^{o}20′ east longitude. From north to south, it extends over 640 km in length from east to west over 480 km in breadth.

Kashmir valley is located in Northwest extremity of India between 32^{o}-17′ and 38^{o}-58′ north latitude and 73^{o}-35′ and 80^{o}-36′ east longitude. Kashmir valley is bounded by inner and outer Himalayan range that includes Nanga Parbat and Pir Panjal ranges, respectively. River Jhelum flows through summer capital. The average altitude of Kashmir valley ranges between 1,500-23,00 m above mean sea level. Kashmir valley is bestowed with temperate climate, winters are severe from December-March. There is wide range of temperature from minimum of -8^{o}C in winter to a maximum of 34^{o}C in summer. Annual precipitation ranges from 676-1193 mm. Forest nursery of the Faculty of Forestry is located between 34′-08^{o} N latitude and 74′.83^{o} longitude, with average mean sea level of 1587 m. Nursery is located at Shalimar campus that is around 14 km southeast to Srinagar city. Nursery has well drained silty loam soil.

3.2 Status and distribution

A detailed survey was conducted to achieve the objective of finding status, distribution and concentration of Indian bean tree in Kashmir valley. Survey was conducted at Panchayat level. Besides it, information was also collected for its socio-economic impact as per Annexure-I. Information from surveyed areas was obtained as per the methodology given below :

a) Questionnaire method : A questionnaire prepared for the purpose was filled on spot during interaction with farmers. It consists of close-ended and open ended questions as per annexure-I.

b) Transit walk method : This is a type of interaction with farmer with free mind while walking through their farms.

c) Informal interview method : This was also an important method of collecting information from the farmers, oldest and respectable citizens of concerned area.

3.2.1 Old Indian bean tree identification

During survey information with respect to old living trees was simultaneously covered either from farmers or departmental persons. Tree was recorded for its location, approximate age, height and girth at breast height. Age was determined with the help of senior citizens or departmental personnel. Clinometer and ordinary measuring tape were used for determining top height of tree and girth respectively. Photographs of identified trees were also taken.

3.3 Maturity indices

During maturation of fruit/seed, it undergoes continuous changes from time to time. The full maturation time is determined by maximum number of viable germinable seeds. Seeds were collected from time to time starting from 15th August from phenotypically identified superior trees situated at Shalimar campus, Botanical garden and Faculty of Forestry. From 15th August, seeds were

continuously evaluated for germination (%), specific gravity, seed weight, change in fruit/seed colour at the intervals of 15 days. Petriplates covered internally at bottom by double fold germination paper were used for germination test. Seeds were placed sparsely and moistened with distilled water regularly in Petriplates. Regular watch and ward was maintained so that petriplates were free of fungal attack. As soon as redicle emerged, seed was considered germinated. Germination per cent was calculated in four replications with 100-seeds in each replication. Germination per cent was calculated as per the following formula :

$$\text{Germination percentage} = \frac{\text{No. of seeds germinated}}{\text{Total No. of seeds}} \times 100$$

3.3.1 Specific gravity

Water displacement method is used to determine specific gravity (Oliver, 1974). Specific gravity of seed was determined by dividing the fresh seed weight by weight of volume of water displaced by same amount of fresh seed. The formula to determine specific gravity is as :

$$\text{Specific gravity} = \frac{\text{Fresh seed weight}}{\text{Weigh of volume of water displaced by same fresh seed weight}} \times 100$$

3.3.2 Seed dimensions

Length and width of filed seeds was recorded with the help of digital caliper. The dimensions of 100 seeds were observed in four replications.

3.3.3 Moisture percentage

Seeds were oven dried at a temperature of 60 ^{o}C till they attained constant weight. M.C. was determined by formula :

$$\text{Moisture \%} = \frac{\text{Fresh seed weight} - \text{Dry seed weight}}{\text{Fresh seed weight}} \times 100$$

[Schubert and Adams, 1971]

3.3.4 Seed weight

Weight of 100 vigour and viable seeds was recorded in 4 replications with the help of sensitive top pan balance. Seeds were regularly weighed at an interval of 15 days from 15th August till 1st week of December.

3.3.5 Fruit/pod colour

Bonner (1972) established a relationship between colour change in fruit/seed and maturation time. Seed collected fortnightly starting from 15th August were continuously observed for colour change to different shades.

3.3.6 Dormancy release

Matured seeds will be used for the purpose and dormancy, if any will be overcomed by following treatment :

i) Stratification at 1^{o}C (cold water treatment)

3.5 Seedling nursery establishment

Seedling nursery of Indian bean tree was raised from healthy and filled seeds in nursery bed, root trainers and polybags.

Open beds of size 1 x 1 m^2 were prepared mixed with FYM and sand, replicated seven times. Date of sowing in beds was last week of March, 2010. The seeds were pretreated with cold water for about 2 minutes before sowing.

Sowing in filled polybags and root trainers was done on same date with same pretreatment. Polybags of size 5″ x 7″ and root trainers of size 300 cc were used for raising the nursery stock. Filling material in both containers was mixture of soil, sand and FYM in ratio of 2:1:1. There were seven replications for each of treatment.

Performance of each treatment i.e. open bed seedlings, root trainers and polybags seedlings were evaluated in term of germination per cent, survival per cent, shoot length (cm), root length (cm), collar diameter of seedling (mm) and

root shoot ratio over one complete growing season. Design was randomized complete block design.

3.6 Vegetative propagation

Semi hard wood cuttings of *Catalpa bignoniodes* were planted at a spacing of 10 x 10 cm and treated with indole butyric acid (IBA) of different concentration viz., 1000, 2000, 3000, 4000, 5000 and 6000 ppm. Length of cutting was 22 cm. experimental design was Randomized Block Design (RBD). Number of replications for each treatment were three. In each replication 30 cuttings were planted that means total number of cuttings were 630 cm.

Performance of each treatment was evaluated by calculation of rooting percentage, survival percentage (at the end of growing season), diameter of leading shoot (mm), number of roots per cutting and length of longest root (cm). The cuttings were planted horizontally in 2nd week of April. Cuttings were covered with soil, pressed tightly and watered after planting. Regular watering was given so that cutting may not dry. Bed was shadowed to prevent desiccation and drying of cutting particularly in and hot earlier stages. Weeding was carried out regularly. The plot size was 1 m x 1 m accommodating 100 cuttings/bed.

CHAPTER – 4

EXPERIMENTAL FINDINGS

The research investigation conducted on "Status and Propagation of *Catalpa bignonioides* (Indian Bean tree) in Kashmir Valley" as per the methology given in the previous chapter has been presented from Table 1 to 6, Figure 1 to 4 and Plate 1 to 6.

4.1 Status and distribution of Indian bean tree (*Catalpa bignonioides*) in Kashmir valley

4.1.1 Identification of oldest existing Indian bean tree in Kashmir

As per survey conducted in Kashmir valley, it reveals that oldest tree was found growing at Cafeteria Park near Achabal Garden in district Anantnag. Approximate age and girth was recorded as 38 to 41 year and 152.40 cm, respectively. Next oldest trees were found in same district in Pahalgam area near Jamia masjid. The age and girth were recorded 19 to 24 years and 103.63 cm. Data about total number of trees in district and location of old tree is given in Table-2 and Plate-2.

4.1.2 Status and distribution

Status and distribution of Indian bean tree was conducted through a detailed survey of all districts of Kashmir valley. Information was collected through casual discussion, during transit walk and by questionnaire method (Annexure – I). During the whole survey it was revealed that Indian bean tree (*Catalpa bignonioides*) was not found on farmlands and wastelands, but was found in aesthetic and recreational places like gardens, parks, roads side plantations, kitchen gardens etc. During the survey it was found that *Catalpa bignonioides* does not contribute to economy of farmers as they do not cultivate it. However, the species in aesthetic and recreational sites are maintained by Government Department. As the farmers do not cultivate it there is no concentrations and no land holding under it.

Table-1 : Phenotypic characteristics of *Catalpa bignonioides* W. trees observed in Kashmir valley

Phenotypic characteristic	Observation
1. Tree habit	Deciduous
2. Tree form	Almost round
3. Average tree height	6-8 metres
4. Bark	Brown to gray
5. Leaves	Long deciduous, Heart shaped 20-30 cm long and 15-20 cm broad.
6. Flower	2.5-4.0 cm across, trumpet shaped, white with yellow spot inside. Full grown flower is 2 lipped and lips are lobed, two above and three below. Flower is perfect.
7. Fruit	20-40 cm long beans like and 8-10 mm in diameter
8. Leaf shedding	Late November
9. Flowering	June-July
10. Colour of flower	White
11. Seed	Papery winged
12. Seed set	From 15 August
13. Seed maturity	Fully mature on 15th November

Table-2 : Status & distribution of Indian bean tree (*Catalpa bignonioides walt.*) in Kashmir valley

S. No.	District	No. of trees found	Avg.ht (meters)	Avg. Girth (cm)	Location of old tree
1.	Srinagar	70	4.12	72.86	Cheshmashahi
2.	Anantnag	42	6.78	88.64	Cafeteria Park Achabal
3.	Baramulla	41	7.2o	94.46	DFO social forestry
4.	Pulwama	29	7.10	95.23	Abhama market
5.	Budgam	19	7.02	95.11	Kralpora near Hr. Sec. school
6.	Bandipora	9	7.23	98.20	KFT (Chitternar)
7.	Kulgam	2	6.91	92.31	Alamdar Colony
8.	Kupwara	2	7.41	88.62	Handwara

Plate-1 : General view of Indian bean tree (*Catalpa bignonioides* Walt.)

Cafteria Park Achabal **Botanical Garden, Cheshmashahi**

Pari Mahal road, Srinagar **Pahalgam near Jamia Masjid**

Plate-2 : Old trees of Indian bean tree (*Catalpa bignonioides* Walt.) found in Kashmir valley

During the survey, it was found that maximum number of plants were found in district Srinagar(70) followed by district Anantnag (42), Baramulla (42), Pulwama (29), Budgam (19), Bandipora (9), Kulgam (2) and Kupwara (2). No tree was found in district Shopian and Ganderbal. Large number of trees are found in Botanical Garden, Cheshmashahi, Nishat Garden, Shalimar Garden, City Park like Iqbal Park; Government Institutes like SKIMS, Soura, Directorate of Agriculture, Lalmandi and SKUAST-K Campus; prominent roads like Humhama airport road, SKIMS road, around roads and Shalimar road. The areas of other districts from where the species of Indian bean tree area located were Kokernag (Anantnag), Achabal, Pahalgam area, Dachnipora (Anantnag), Kashmir Training Institute (KFT), Chitternar (Bandipora), Gulnar Park (Baramulla), DFO Social Forestry and DG Office, Baramulla, Cafeteria Park, Anantnag (Appendix – I).

4.2 Maturity indices

Time of flowering, seed formation and their maturation are important thing in studying the maturity of any tree seeds. The studies undertaken for Indian bean tree revealed that in Indian bean tree flowering starts from late June to early July when the flowers of other trees have mostly faded. The flowers are trumpet shaped, white with yellow spots inside growing in panciles of 20-40. Flower is two lipped and lips are lobed, two lobes above and three lobes below. The fruit i.e. pod is long, thin bean like pod with 15-50 cm long and 8-10 mm diameter, often stays attached to tree during winter. The pod contains numerous flat light brown or silvery grey seeds. The pod set take place from 15 July onwards and attains full size in early August. The colour of pod changes from green to brownish red while that of seeds changes from green to light brown or silvery grey by late October.

To study the maturity indices i.e. indicators for better germination, seeds were collected regularly from phenotypically superior trees from mid August till maturation at an interval of 15 days. The seeds were collected together from the selected trees. During the research it was revealed that collection dates have

remarkable effect on colour, seed weight, seed size, moisture content, specific gravity and germination per cent.

4.2.2 Colour

The change in colour was observed at each collection. The colour as observed through ocular observation was green in mid August and changes to light brown with greenish orange by mid September and finally silvery grey by mid October. Thereafter no further change in colour was observed (Table-3, Plate-3).

4.2.3 Seed weight

During initial collection (1st week of August) when the seed colour was green, seed weight per 100-seeds was recorded 4.65 g, after 30 days i.e. by mid September seed weight per 100-seeds was 4.96 g which was highest, thereafter it starts decreasing due to drying of seeds and on mid October seed weight per 100 g was recorded 3.13 g. furthermore it declined continuously reaching a minimum value of 2.32 g/100-seeds by mid November (Table-3, Fig. 1).

4.2.4 Specific gravity

It is evident from the Table-3, Fig. 1 that specific gravity at first increases upto mid September after that it starts decreasing reaching a minimum value of 0.21 by 1st week of December. During the first seed collection i.e. mid August, specific gravity of 0.58 was recorded and thereafter increases and reaches 0.63 on mid September, 0.65 by 1st week of September and then decreased to 0.44 in 1st week of October, 0.34 value by mid October, 0.29 by 1st week of November and finally 0.21 during 1st week of December.

Table-3 : Indicators for maturity of seeds (*Catalpa bignonoides*) collected on different during 2010

S. No.	Date of collection	Colour	Seed weight per 100-seeds	Specific gravity	Moisture (%)	Seed dimensions (mm)		Germination (%)
						Length	Breadth	
1.	15th August	Green	4.65	0.58	50.8	40.8	4.11	0
2.	1st September	Green	4.77	0.63	42.30	42.30	4.35	0
3.	15th September	Light brown	4.96	0.65	37.90	38.80	4.23	11.25
4.	1st October	Light brown to silvery grey	4.31	0.44	32.75	33.90	4.00	45.60
5.	15th October	Silvery grey	3.13	0.34	28.12	31.9	3.98	62.31
6.	1st November	Silvery grey	2.70	0.29	18.51	28.46	3.95	69.10
7.	15th November	silvery grey	2.32	0.24	9.69	24.46	3.92	89.40
8.	1st December	Silvery grey	2.32	0.21	8.34	24.46	3.92	88.90
$CD_{(0.05)}$			0.45	0.23	1.48	1.65	0.22	2.29

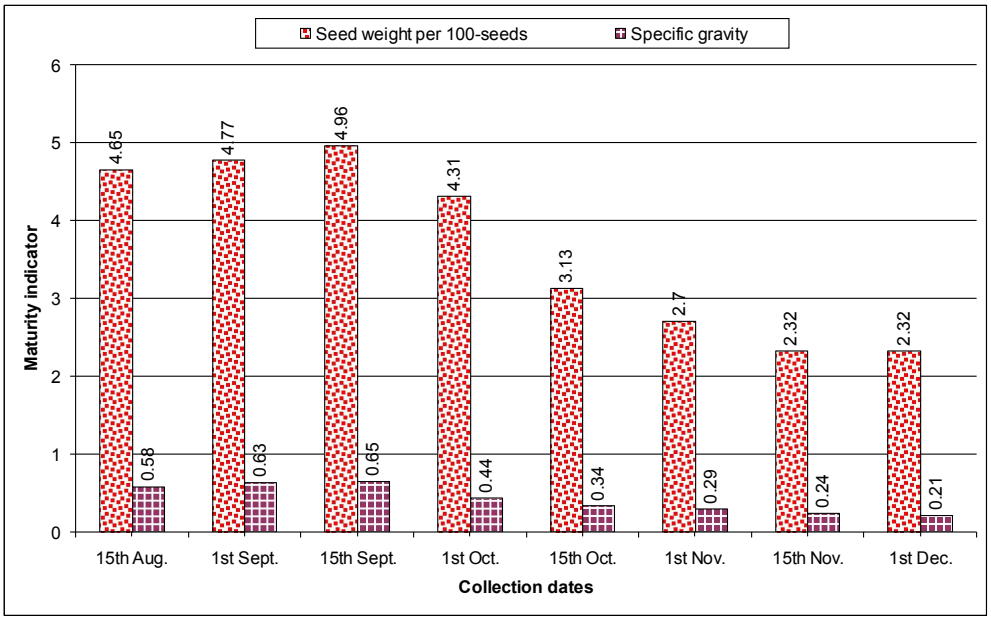

Fig. 1 : Indicators for maturity of seeds of Indian bean tree (*Catalpa bignonoides*) collected on different dates during 2010

Green

Silver Grey

Dark Green

Brownish Red

Plate-3 : Colour changes in seeds and pods of (*Catalpa bignonioides* Walt.)

4.2.5 Moisture content

Moisture content shows a declining trend throughout the collection period. The highest value for moisture content was recorded as 50.8 per cent on mid August. After that, it showed a declining trend i.e. 37.9 per cent in mid September, 28.12 per cent in mid October and finally 8.34 per cent in 1st week of December (Table-3, Fig.2).

4.2.6 Seed dimensions

The seed dimensions (length and breadth) varied with each collection. The average length and breadth of seeds recorded in mid August were 40.8 and 4.11 mm, respectively. The seed size increased initially and attained maximum length and breadth in 1st week of September. Thereafter the seed size decreased from mid September onwards. The minimum length and breadth of seeds i.e. 24.46 and 3.92 mm were recorded in mid November and remained constant thereafter (Table-3).

4.2.7 Germination per cent

Initially no germination was recorded in the beginning from mid August to 1st week of September when the seed colour was green. With the onset of colour change, germination also commenced and reached to maximum of 89.4 per cent by mid November and thereafter the germination per cent decreased.

4.3 Dormancy of seed

Seeds collected at maturity were subjected to germination test in incubator at 21±1^{o}C. The test period was run till nearly complete germination was obtained. The observations were taken with respect to germination (%). The seeds germinated completely within a week which suggested that seeds of Indian bean tree are not having any kind of dormancy. However, germination per cent can be increased by treating seeds with cold water treatment for at 1^{o}C (cold stratification). Study revealed that fully matured seed collected in mid November when subjected to germination test, germinates to 89.44 per cent and the same seeds when soaked in cold water for few minutes germinates to 92.07 per cent (Table 4, Plate-4). The study revealed that both the treatments are at par with each other suggesting that the seeds of Indian bean tree is not having any kind of dormancy.

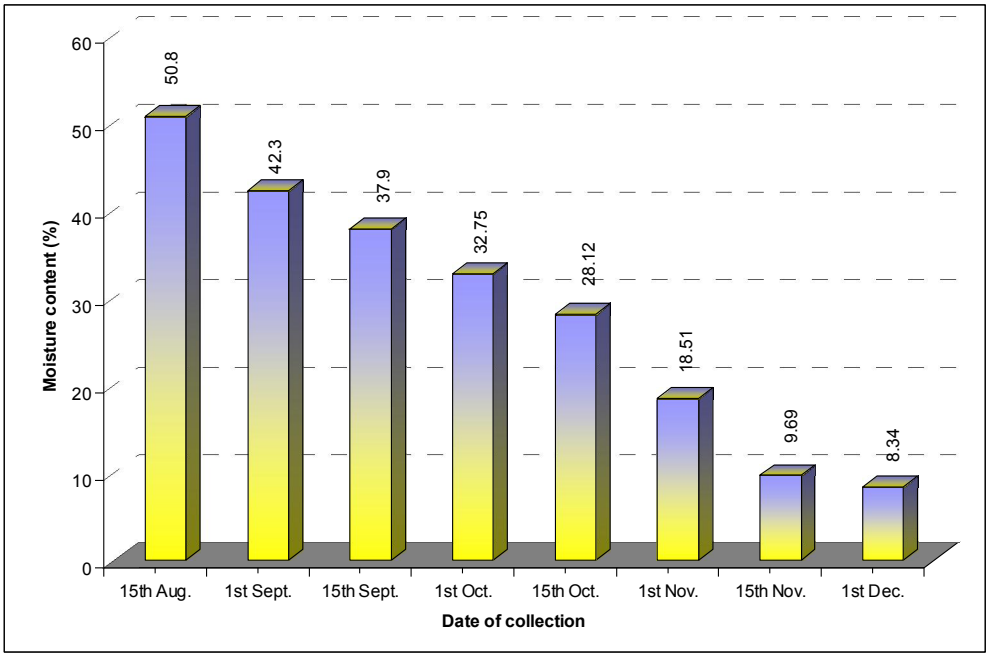

Fig. 2 : **Moisture content (%) as an indicator of seed maturity of Indian bean tree (*Catalpa bignonoides*) collected on different dates during 2010**

Plate-4 : **Seed Germination of Indian Bean Tree under laboratory conditions**

Table-4 : Effect of different treatments on germination of Indian bean tree

Treatments		Germination (%)
1.	Fully matured seed (collected on mid November)	89.44 (71.14)
2.	Seeds soaked in cold water for few minutes	92.07 (73.88)
CD		NS

Data in parentheses are arc sine transformation

4.4 Nursery raising through seeds

The seeds of *Catalpa bignonoides* were sown in open beds, polybags (5″x7″) and root trainers of size 300 cc. The experimental observation taken with respect to seedling nursery i.e. nursery of open bed, polybags and root trainers (Table-5, Fig. 3, Plate-5) are presented as under :

4.4.1 Germination percentage

It is evident from the Table-5 that the germination percentage varied in all the three treatments. The maximum germination percentage of 94.63 was recorded in root trainer 300 cc which was statistically at par with 92.43 in polybags. The minimum germination of 65.14 per cent was recorded in open nursery beds.

4.4.2 Shoot height

As per analysis of data presented in Table-5, it is found that maximum shoot height of 27.08 cm was attained by polybags which was statistically at par with 25.02 cm in root trainers (300 cc). The lowest shoot height of 12.64 cm was found in seedlings raised in nursery bed. Thus shoot height in case of open nursery bed differ significantly from other two treatments.

4.4.3 Root length

The root length showed the similar trend as that of shoot height. The analysed data revealed that root length (cm) of three treatments i.e. nursery bed, polybag and root trainers are 9.19, 22.75 and 16.94 cm, respectively. It clearly shows that highest value is obtained by polybags and lowest value is obtained by nursery bed. The analysed data revealed that mean value of three treatments i.e. nursery bed, polybag and root trainers differ significantly from each other (Table-5, Plate-5).

Table-5 Performance of seedlings in terms of below tabulated parameters of Indian bean tree (*Catalpa bignonioides* Walt.) in open nursery bed, polybags and root trainers

Treatment	Germination (%)	Shoot height (cm)	Root length (cm)	Collar diameter (mm)	Root shoot ratio (dry weight basis)	Survival (%)
T_1 Nursery bed	65.14 (53.90)	12.64	9.19	2.07	0.49	48.29 (44.01)
T_2 Polybag	92.43 (74.52)	27.08	22.75	4.36	0.58	70.29 (57.08)
T_3 Root trainer	94.63 (76.99)	25.02	16.94	3.93	0.51	85.37 (67.59)
$CD_{(0.05)}$	4.92	3.95	4.15	0.49	0.07	3.918

Data in parentheses are arc sine transformations

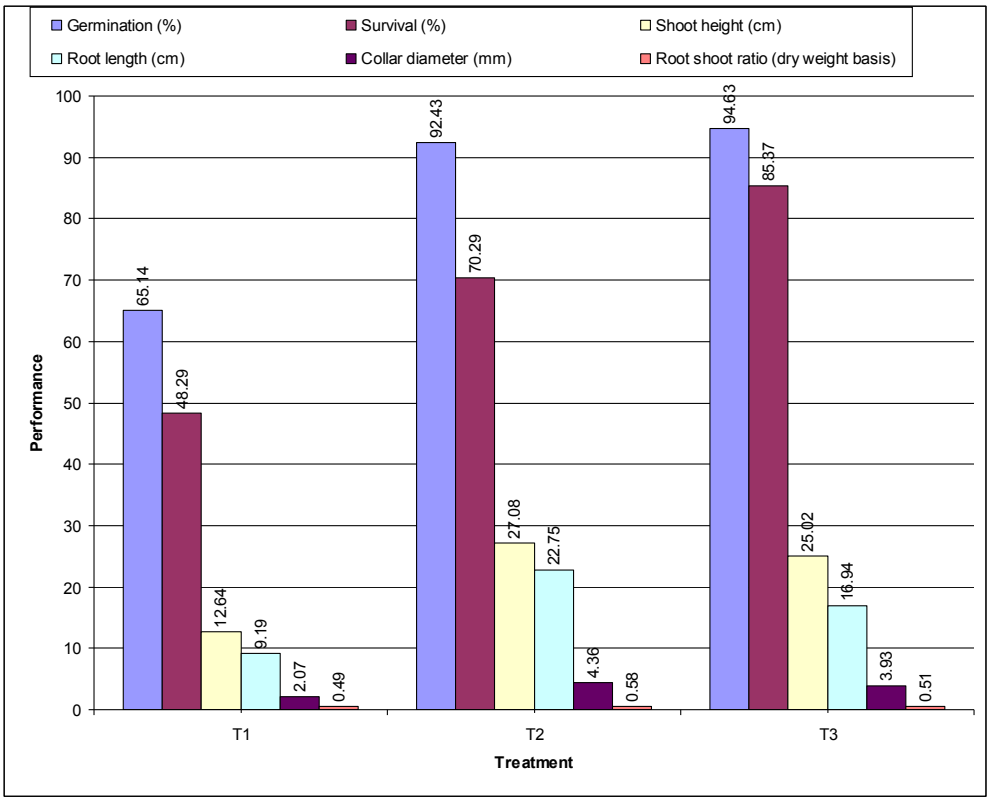

Fig. 3 : **Performance of seedlings in terms of various parameters of Indian bean tree (*Catalpa bignonioides* Walt.) in open nursery bed, polybags and root trainers**

T_1 = Nursery bed; T_2 = Polybag; T_3 = Root trainer







Nursery bed **Polybag** **Root trainer**

Plate-5 : Performance of seedlings of Indian bean tree (*Catalpa bignonioides* Walt.) grown in nursery

4.4.4 Collar diameter

It is evident from the Table-5 that maximum collar diameter of 4.36 mm was exhibited by the seedlings raised in polybags which was statistically at par with 3.93 mm in the seedlings raised in root trainers 300 cc. the lowest value of 2.07 mm was recorded in open nursery beds.

4.4.5 Root shoot ratio

Perusal of data tabulated in Table-5 showed that treatments differ significantly with each other for root shoot ratio. The highest value of 0.58 was obtained in polybags which was statistically at par with 0.51 in root trainer 300 cc. the lowest value of 0.49 for root shoot ratio was recorded in nursery beds.

4.4.6 Survival percentage

Survival of the seedlings showed the similar trend as that of germination percentage. It is clear from the Table-5 that root trainers exhibit the highest survival percentage of 85.37 whereas lowest survival percentage of 48.29 was found in open nursery beds. The data revealed that significant differences are found between the survival percentage of three treatments i.e. nursery bed, polybags and root trainers.

4.5 Vegetative propagation

Semi-hardwood cuttings of pencil thickness and 9 inches in length were used for vegetative propagation. Cuttings were taken from well grown trees and treated with rooting hormone IBA with different concentration viz. 1000, 2000, 3000, 4000, 5000 and 6000 ppm. The observation taken with respect to vegetative propagation are is shown in Table-6, Plate-6.

4.5.1 Rooting percentage

It is evident from the Table-6, Fig. 4 that there was a great variation in sprouting percentage of the cuttings. The maximum sprouting percentage of 65.08 per cent was recorded in cuttings treated with 4000 ppm IBA which was statistically at par with 55.94 per cent in 5000 ppm IBA. The lowest value of

20.14 was recorded in control. The rest of the IBA concentration does not show any significant difference.

4.5.2 Diameter of leading shoot (mm)

The analysed data shown in Table 6 for collar diameter of leading shoot (mm) revealed that highest collar diameter of 2.48 mm of leading shoot was found in case of 4000 ppm IBA treated cuttings and lowest was found in control. The data analysis showed that treatment T_1 (1000 ppm), T_2 (2000 ppm), T_3 (3000 ppm), T_4 (4000 ppm), T_5 (5000 ppm) and T_6 (6000 ppm) differ significantly with treatment T_7 i.e. control, also treatment T_3 and T_4 showed significant difference with each other. Rest of treatments T_1, T_2, T_4, T_5 are statistically at par with each other.

4.5.3 Number of roots/cutting

The analysed data showed that highest number of roots per cuttings are found in treatment T_4 i.e. cuttings treated with 4000 ppm IBA and lowest number of roots/cutting are found in control conditions i.e. T_7. The data showed that rest of treatments except control (distilled water, T_7) are statistically at par with each other. Cuttings treated with distilled water (T_7) differ significantly with rest of the treatments.

4.5.4 Length of longest root

The perusal of data in Table 6 revealed that highest length of 11.74 cm of longest root was found in cuttings treated with 4000 ppm IBA which was statistically at par with 10.42 cm in cuttings treated with 5000 ppm IBA. The lowest value was recorded in control.

4.5.5 Survival percentage

The survival percentage also showed the similar trend with maximum survival percentage of 44.86 per cent in cutting treated with 4000 ppm IBA which was statistically at par with 35.33 per cent in cutting treated with 5000 ppm. Thereafter the survival percentage showed the decreasing trend. The lowest value of 0.00 per cent was recorded in control (Table 6, Fig. 4).

Table-6 : Vegetative propagation of Indian bean tree (*Catalpa bignonioides* Walt.) through stem cuttings

Treatments		Rooting (%)	Diameter of leading shoot (mm)	No. of roots pry.+sec. +try./ cutting	Length of longest root (cm)	Survival (%)
T_1	IBA (1000 ppm)	40.80 (5.83)	1.53	152	7.07	24.10 (4.47)
T_2	IBA (2000 ppm)	34.62 (5.43)	1.69	160.67	8.14	19.82 (4.80)
T_3	IBA (3000 ppm)	48.46 (6.91)	1.63	181.00	9.09	34.18 (5.42)
T_4	IBA (4000 ppm)	65.08 (8.22)	2.48	204.67	11.74	44.86 (6.29)
T_5	IBA (5000 ppm)	55.94 (7.10)	2.14	182.33	10.42	35.33 (5.76)
T_6	IBA (6000 ppm)	44.64 (6.86)	1.95	162.00	9.66	31.16 (5.42)
T_7	Control (distilled water)	20.14 (2.95)	0.00	0.00	0.00	0.00 (0.00)
$CD_{(0.05)}$		2.21	0.44	60.22	2.52	1.30

Data in parentheses are transformed value

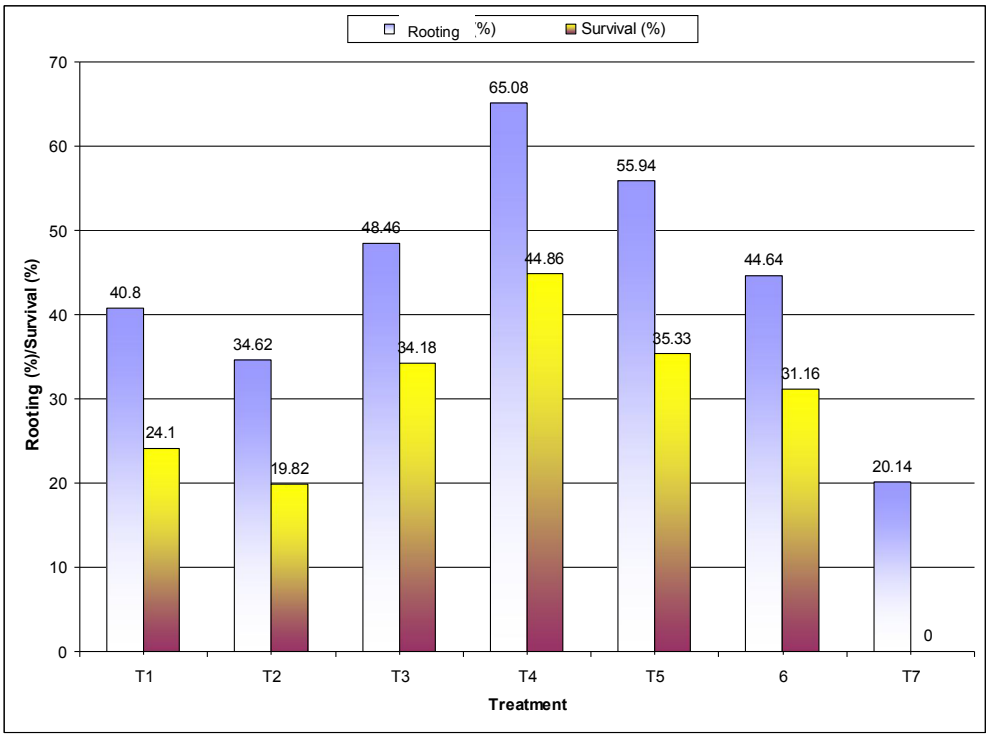

Fig. 4 : **Rooting and survival percentage of Indian bean tree (*Catalpa bignonioides* Walt.) through stem cuttings**

T_1 = IBA (1000 ppm), T_2 = IBA (2000 ppm), T_3 = IBA (3000 ppm), T_4 = IBA (4000 ppm), T_5 = IBA (5000 ppm), T_6 = IBA (6000 ppm), T_7 = Control (distilled water)

3000 ppm 4000 ppm 5000 ppm

Plate-6 : **Vegetative propagation of Indian bean tree (*Catalpa bignonioides* Walt.) cuttings treated with IBA**

CHAPTER – 5

DISCUSSION

Jammu and Kashmir is called paradise on earth. Climate of state varies from subtropical to temperate to subalpine. Jammu and Kashmir is a mountainous valley located in north of Indian Republic. It is phytogeographically most complex and diverse. Due to great diversity in climate and altitude nature has bestowed it with large number of tree species, shrubs and herbs etc. It is worth to mention that forests are renewable resources influencing substantially to physical and socio-economic development of a society. Due to ever increasing population of the state, forests have been placed under tremendous pressure arising out of increasing demand for fuel wood, fodder, timber and other forest products, resulted in acute degeneration of forest resources of state. Therefore, present challenge is to stop degradation of our forest resources to maintain ecological balance and simultaneously meeting challenges of increasing demand of forest products and unemployment.

Indian bean tree has got immense importance as ornamental plant due to the shape of the tree, leaf shape and size and above all having showiest flowers. The tree is adapted to sandy, loamy, clay soils, prefers acidic soils, neutral and alkaline soils, requires moist soils meaning that tree can grow at every place and can tolerate atmospheric pollution (Chittenden, 1951, Bean, 1981). The tree grows with large biomass. Species has importance in tourism sector. Tree species increases the beauty of parks, roads, kitchen gardens. Tree species will also ensure supply of fuelwood, and timber at the same time it can be planted in sites which are most frequent subjected to landslides as it can stabilize soil due to its extensive root system. Despite, above mentioned importance of tree species in valley and throughout temperate world, there is no documented information with respect to its status and propagation. Keeping that in mind, a project entitled “Status and Propagation of Indian Bean Tree in Kashmir Valley” was undertaken to study

status, distribution and to address the problems of propagation. The studies were carried out in the Faculty of Forestry, SKUAST-K, Shalimar during 2010-11 as per the methodology and materials used and described in Chapter 3.

5.1 Status and distribution

To determine status and distribution, survey was conducted in all districts of Kashmir valley at Panchayat level. Information was collected through casual discussion, transit walk and questionnaire method. During the whole survey, it was revealed that Indian bean tree (*Catalpa bignoniodes*) was not found on farmlands and wastelands, but was found in places of having tourism value like gardens, parks, roadside plantation, kitchen gardens under different edaphic, physiographic and microclimatic conditions. During the survey it was found that catalpa does not contribute to economy of farmers as they do not cultivate it probably of the reason that, farmers are not aware about this species. Species has important place in urban forestry. As the farmers do not cultivate the tree species there is no concentration and no land holding under it. During the survey it was found that maximum plants are found in district Sriangar (70) followed by district Anantnag (42) and Baramulla (41). No tree was found growing in district Shopian and Ganderbal. Information about other districts is given in Table-2. Oldest tree was found in district Anantnag fallowed by district Baramulla.

The tree has got immense importance in urban forestry as it increases beauty of aesthetic and recreational sites due to shape of tree, shape of leaves, attractive showy flowers and late blooming nature.

5.1.1 Identification of oldest existing trees

Extensive survey was conducted to locate the old existing tree in Kashmir valley. The old existing trees which are identified in different districts of valley are presented in Table-2.

Oldest tree was found in Cafeteria park near Mughal garden in Achabal in district Anantnag. The approximate age and girth of tree was recorded as 38 to 41

and 152.40 cm, respectively. Next oldest tree was found in Pahalgam Park in same districts.

During the survey it was concluded that old trees are maintained in Govt. parks or in premises of Govt. establishments where they remain safe. No tree was found in farm lands. This is due to non-familiarity of farmers to tree species.

5.2 Maturity indices

During study of maturity indices it was concluded that flowering starts from late June to early July when the flowers of other tree species have faded mostly. The flowers are trumpt shaped, white with yellow spot inside, growing in panicles of 20 to 40. The pod is long, thin bean like, 15 to 50 cm long and 8 to 10 mm diameter. Pod set took place from 15 July onwards and attains full size by early August. The colour of pod changes from green to brownish red while that of seeds changes from green to light brown or silvery grey by late October.

Seed maturity indicators help in collection of viable and mature seeds in large quantities to avoid the loss due to non-germination of seeds. Seeds were regularly collected from 1st week of August at intervals of 15 days. The data collected is presented in Table-3 showing that date of collection have prominent effect on colour, seed weight, specific gravity, moisture content and seed dimensions.

5.2.1 Fruit/seed colour

During observation, it was concluded that seed colour remains green from mid August to 1st week of September and no germination was recorded. Thereafter, colour changes to light brown by mid September after which no further change in colour was observed till 1st week of October. With advancement in colour changes, germination also increases and was recorded 11.25 per cent by mid 15th September to 89.40 per cent by mid November thereafter it decreases. It clearly indicates that change in colour gives a clue towards maturity of seeds of catalpa. As already explained by Williams (1985) that colour change in cone/fruit

is a reliable criteria for judging maturity of seed. A relationship is often established between maturity and their colour, which is used to identify physiological maturity of tree seed such as in *Liquidampar styraciflua* and *Platinuss orientalis* (Bonner, 1972) and in *Quercus* species (Bonner, 1974). During maturity when colour change was recorded silvery grey by mid November germination was recorded maximum.

5.2.2 Seed weight and seed dimensions

Seed weight and seed dimensions varies with each collection period. Seed weight/100 seed was recorded 4.65 gm on mid August and seed dimensions were 40.8 mm and 4.11 mm on the same date. Further these parameter increases and seed weight attains maximum value on 15th September (4.96 gm/100 seeds) and seed dimensions were maximum on 1st September (42.3 mm and 4.35 mm). Increase in seed weight and seed dimensions despite the fact the moisture content shows decreasing trend throughout the collection period could be attributed to the synthesis and accumulation of food resources. However, on 15 September and 1st October seed dimensions and seed weight starts decreasing, respectively due to loss of moisture in reaching the full maturity of seed as it confirms with seed maturity is closely related with decline in moisture per cent of seed (Adam and Rinnie, 1981, Pandit *et al.*, 2002).

5.2.3 Specific gravity

Specific gravity was recorded 0.58 at the first time of collection on 15th August. After that specific gravity increases and reaches a maximum value of 0.65 on 15th September. Specific gravity during the whole collection period varied between 0.58 to 0.21. The seed collected on 15th November shows maximum germination per cent for which specific gravity is 0.24. Declining specific gravity and increasing seed germination are related as explained by varies works in conifer species (Maki, 1940; Fowells, 1949; Cram, 1956; Pfister, 1967; Oliver, 1974 and Singh, 1998) with further decrease in specific gravity from 0.24 to 0.21

on 1st December, germination also decreases little bit to 88.9 per cent from 89.4 per cent. This may be to hard seed coat or presence of inhibitors on he surface of seed (Hartman and Kester, 1976).

5.2.4 Moisture content

Moisture percentage shows a declining trend throughout the collection period. Maximum germination occurs when seed moisture content decreases to a value of 9.69 per cent, after that germination decreases with further loss of moisture and was recorded 88.40 per cent at moisture percentage of 8.64 per cent on 1st December. The maximum germination (89.40%) was observed when seed moisture content was 9.69 per cent. Singh and Kachari (2006) reported that germination per cent of seeds increases with decreasing moisture content in cones of *Pinus kesiya* (Khasi pine).

5.3 Dormancy release/enhancement of germination per cent

During the course of maturity indices, it was observed that maximum germination of 89.4 per cent was recorded when seeds were collected during mid November. It was also observed that seed starts germinating from 3rd day of sowing and germination got completed. Thereafter no change in germination per cent was observed indicating that there is not any kind of dormancy in seed. However seed germination can be increased/ enhanced by dipping the seed in cold water treatment at 1°C. The results are in confirmation with research of Hartman and Kester (1976) who reported that purpose of soaking seeds in water is to modify hard seed coat, remove inhibitors, soften seed coat and reduce the time of germination of seeds of *Cassia fistula* (Amaltas).

5.4 Nursery raising through seed

Plantations offer the means of using large scale, the genetically improved material developed by tree breeders with few exceptions like populus and willow trees are generally propagated from seeds and the suitability and quality of seeds have a major role on the success of plantation relief thereof. The use of sound

seeds from stands of high inherent quality is widely recognized as the best means of ensuring fast growth and healthy plantations capable of yielding high quality wood.

Studies conducted on the nursery raising revealed that signficiant differences were observed in terms of germination percentage, survival, seedling height, root weight (fresy/dry) and shoot weight (fresy/dry). Growth parameter viz. germination (%) and survival (%) were found maximum in root trainers whereas root shoot ratio, shoot height, root length and collar diameter were maximum in polybags. The findings are in conformity with Kumar *et al.* (2005) who studied the nursery growth parameters in *Pinus roxburghi* raised in different containers. Biomass parameters increased with increase in container size and were maximum in polybags. However, biomass parameter were highest in hiko tray raises *Pinus roxburghi* plants.

Qaiser and Mishra (2005) studied the nursery performance of *Acacia catechu* seedlings raised in different types and size of containers. The bottom perforated polybags and root trainers raised seedlings depicts better value of seedlings quality parameters viz., sturdiness, root/shoot ratio and Dickson quality index, which indicted the overall quality of seedlings.

Gera *et al.* (2007) worked out on comparative study on the quality of bamboo seedlings raised in root trainers and polybag kept on iron bed. The seedlings raised in 300 cc root trainers showed better quality parameters compared to almost same sized polythene bags.

5.5 Vegetative propagation

Vegetative or asexual propagation is used to produce true to type plant material. It is most convenient, easiest and economical method of propagation for some important crops (Hartman *et al.*, 1993). Production of nursery through stem cuttings is particularly suitable for species where species has differently in propagation through seeds.

Vegetative propagation studies conducted on *Catalpa bignonioides* stem cuttings revealed that all parameter studied viz., rooting percentage (60 %), survival percentage (40%), diameter of leading shoot (2.48 mm), number of roots/cutting (204.67) and length of largest root (11.74 cm) attains superiority in cuttings treated with 4000 ppm IBA (T_4). These findings are at par with the work done by Mumtaz *et al.* (2009) who studied the vegetative propagation of *Aesculus indica* through stem cuttings treated with different concentrations of IBA. The study revealed that maximum rooting percentage and sprouting (%) was recorded in cuttings treated with 4000 ppm IBA. The results are also in line with Siddiqui and Hussian (2007) who studied the effect of different concentrations of IBA on *Ficus Hawaii* Softwood, semi-hardwood and hardwood cuttings were treated with 0, 1000, 2000, 3000, 4000 and 5000 ppm IBA and concluded that maximum sprouting, leaves per plant, plant height, shoot per plant, leaf area, shoot thickness, root length and root per plant was recorded in cuttings treated with 4000 ppm IBA as compared to control.

CHAPTER – 6

SUMMARY AND CONCLUSION

Catalpa bignonioides Walter. is species of Catalpa belonging to family bignoniaiceae (order lamiales) is native tree of southern United States in Alabama, Florida, Georgia, Louisiana, Mississippi, commonly called southern Catalpa. The tree has vitality enabling it to flourish in northern hemisphere as well. Indian bean tree is among ornamental tree, adapted to all types of soils can tolerate atmospheric pollution. The tree is widely grown as ornamental tree having distinction of being some of showiest flowers, thus holding associated place in Aesthetic and Recreational sites like roads of all temperate countries. Bark has antiseptic properties, antidote to snake bites, sedative and vermifuge properties. Due to extensive root system of plant species it has been planted in lands that are so subjected to landslides to stabilize soil. Wood is used for fence posts, and soil road ties being a tree of immense potential for Tourism and Urban Forestry, research studies entitled as, "Status and Propagation of Indian Bean tree (*Catalpa bignonioides)* in Kashmir Valley" was undertaken at Faculty of Forestry, SKUAST-K, Shalimar during 2010-2011 with following objectives :

1) Status and distribution

2) Propagation through a) Seed, b) Cuttings.

The results obtained and analyzed data discussed in previous chapters are summarized and concluded below :

- Indian bean tree (*Catalpa Bignonioides* Walt.*)* was found growing in aesthetic and recreation site like public or private parks, roadside plantations in the premises of government departments.
- Farmers do not cultivate it because of poor knowledge about this species and being of exotic nature. Other reasons of non cultivation may be its slow growth or due to its non fodder nature as it leaves

are bitter. Plants growing in aesthetic and recreational sites are maintained either by Tourism Dept. or Urban forestry department.

- As farmers are not aware about to Indian bean tree, tree does not play any role in economy of farmers nor farmer possess any land under it.
- Oldest trees were found in district Anantnag near Cafeteria Park, Achabal. Approximate age and girth of oldest tree was 38-41 years and 152 cm, respectively.
- Maximum number of trees species are found in District Srinagar maintained either by urban forestry department, by Tourism or Roads and Building department.
- Maturity indices studied revealed that the best time of seed collection in *Catalpa bignonioides* is 3rd week of November when the seeds have attained silvery grey colour and germination of 89.4 per cent.
- Seeds germinate quickly indicating that seeds do not posses dormancy. However, germination percentage can be increased by soaking the seeds in cold water for few minutes.
- Nursery study revealed that germination and survival per cent was found highest in Root trainers and rest of parameter viz. Shoot height, Root length, Collar diameter and Root Shoot ratio had attained highest value in polybags. Root trainers attained 94.63 and 85.37 per cent germination and survival percentage respectively. Polybags attained 27.08, 22.75, 4.36 and 0.58 Shoot height, root length, collar diameter, and root shoot ratio, respectively.
- Vegetative propagation data of stem cuttings after analysis revealed that maximum growth was attained by 4000 ppm treated cuttings

(T_4) in terms of sprouting percentage (60), survival percentage (40), collar diameter of leading shoot (2.48 mm), number of roots/cuttings (204.67) and length of largest root (11.43 cm).

CONCLUSION

- Farmers do not cultivate the Indian bean tree due to unawareness about the tree species. Tree species is mostly found in aesthetic and recreational places maintained by Government Departments.
- Old trees were found in District Anantnag near Cafeteria Park (Achabal) and largest number of trees are found in district Srinagar.
- Development of maturity indices showed that seeds attain maturity by 3rd week of November having silvery colour and highest germination percentage.
- There is not any kind of dormancy in seeds of Indian bean tree.
- Seedling grown in root trainers had best germination and survival percentage where as seedlings grown in polybags got vigorous results in terms of shoot height, root length, collar diameter and root shoot ratio.
- Stem cutting treated with 4000 ppm IBA (T_4) resulted in production of superior and vigorous planting stock.

RECOMMENDATIONS

- Propagation through seed should be given preference than vegetative propagation because of better results and cost benefit method.
- Standardization propagation technique for Kashmir valley worked out through this project should be made use of during its propagation and same should be disseminated to concerned departments.

- Oldest tree identified should be declared heritage tree and measures should be taken to protect them.
- Steps should be taken to raise its plantations artificially up to the limited where it can perpetuate itself naturally.
- As farmers are unaware about the species, they should be made aware about the species for its plantation large scale so that they get motivated to plant it.
- Indian Bean tree is late blooming and attractive; having important place in aesthetic and recreational forestry; better marketing of seedlings, unemployed youths should be motivated for nursery propagation of this species to enhance their income.
- The tree species has potential to grow everywhere, it should be used for social forestry projects on large scale.

LITERATURE CITED

Adams, L.A. and Rinnie, R.W. 1981. Seed maturation in soyabean (*Glycine max* L. Merr) is independent of seed mass and of parent plant. Yet in necessary for production of viable seeds. *Journal of Ex. P. Bot.* **32** : 615-620.

Anonymous, 2010. Annual Administrative Report. Jammu and Kashmir Government Forest Department, Srinagar, Jammu and Kashmir, p. 8.

Anonymous, 2010. http://www.tribuneindia.com2do/j&k.

Barton, L.V. 1935. Storage of some coniferous seed. *Contribution Boyce Thompson Institute* **7** : 379-404.

Barton, L.V. 1965. Seed dormancy, general survey of dormancy types in seed and dormancy imposed by external agents. *Encyclopedia of Plant Physiology* **15**(2) : 699-720.

Baul, T.K., Mezbahuddin, M. and Mohiuddin, M. 2008. Effect of different hormones on root growth of *Stereospermum suaveolens* DC. *Journal of Plant Biotechnology* **37** : 275-283.

Bean, W. 1981. Trees and shrubs hardy in great Britain. Vol. 1-4 and supplement Murray.

Bhat, G.M., Khan, M.A. and Mughal, A.H. 2007. Seed maturity indices on elm (*Elmus waallichiana*, Planchon) : A multipurpose tree species of

Kashmir valley. *International Journal of Ecology, Environment and Conservation* **13**(3) : 473-476.

Bonner, F.T. 1972. Maturation of acorns of sweet gums and America sycamore seeds. *Forest Science* **18** : 223-231.

Bonner, F.T. and Graney, D.L. 1974. Catalpa. **In** : *Schopymeyercs, tech. cord. Seeds of woody plants in United States*. Agric. Handbook 950. Washington, D.C. USDA Forest Service 18/B 283.

Brant, R.E., Mckee, G.M. and Cleven Land, R.W. 1971. Effect of chemical and physical treatments on hard seed of *Penngifterown vetch*. Crop Science **47** : 1-6.

Chiej, R. 1984. Encyclopedia of Medicinal Plants. Macdonald ISBN 0356-10541-5.

Chittendon, F. 1951. RHS dictionary of plus supplement. Oxford University Press.

Chittendon, F. 1956. RHS Dictionary of Plus Supplement. Oxford University Press.

Cobb, H.C. 1959. Seed collection and processing. **In** : Direct seedling in the south, 1959. Dube University Symposium, pp. 40-46.

Cram, W.H. 1956. Maturity of *Coloraclo spruce* cones. *For. Sci.* **2** : 26-30.

Donelly, E.D. 1970. Persistance of hard seed in *Vicia lines* derived from linter specific hybridization. *Crop Science* **10** : 661-662.

Endean, F. and Carlson, L.W. 1975. The effect of rooting volume on the early growth of lodge pole pine seedlings. *Can. J. For Res.* **5** : 55-60.

Flint, L.M. and McAlister, E.D. 1937. Wavelength of radiation in the visible spectrum promoting the germination of light sensitive lettuce seeds. Smithsonean Inst. M.Sc Collections **76** : 1-8.

Fowells, H.A. 1949. An index of responses of sugar pine seed. USDA. Fod Serc. *Forest and Range Exp. Sta. Res.* **64** : 1-5.

Francis, J.K. 1993. Seeds of Puerto Rican trees and shrubs : Second installment Res. Note So-374. New Orleans : USDA Forest Science, Southern Forest Experiment Station, p. 5.

Gautam, J. and Bhardwaj, S.D. 2001. Effect of seed size and presowing treatments on germination of bban oak (*Quercus leucotrichophora*). *Indian Journal of Forestry* **24**(3) : 311-315.

Gera, M., Koul, A.R. and Gera, N. 2007. Comparative study on quality of bamboo seedlings in root trainers and polythene bags. *Indian Forester* **133**(3) : 306-312.

Harrington, J.F. 1970. Seed and pollen storage for conservation of plant gene resources. **In** : *Genetic Resources in Plant, their Exploration and Conservation*. Handbook No. 11. International Biological Programme, London.

Harrington, J.F. 1972. Seed storage longitivity. *Seed Biology* **3** : 145-146.

Hartman, H.T., Kester, D.E. and Daves, F.T. 1990. Plant propagation principles and practices. V. Edition Reagent/prentice Hall Engle Wood Cliffs New Jersey 07932.

Hartman, H.T., Kester, D.E. and Davis, F.T. 1993. Plant propagation principles and practices. VI editing prentice Hall of India, New Delhi, 190001, p. 165.

Hartmann, H.T. and Kester, D.E. 1976. Plant propagation principles and practices. Prentice Hall, New Delhi, 662 p.

Heit, C.E. 1961. Abnormal germination during laboratory testing in coniferous tree seed. *Proceedings Institute Seed Testing Association* **26** : 419-427.

Hellum, A.K. 1978. The growth of planted spruce in Alberta. Proceedings of the root form of planted tree symposium. *Canadian Forest Service Report* No. 8, Victoria, B.C., pp. 191-196.

IBPGR, 1976. Report of IBPGR working group of engineering, design and cost aspect of long term storage facilities. International Board of Plant Genetic Resources, Rome.

Janick, J. 1974. Horticulture Sciences. W.H. Freeman and Co., USA, p. 188.

Keeler, H.L. 1900. Our native trees and how to identify them. New York. Charles Scriber's Sons, pp. 225-228.

Kishwan, J., Pandey, R. and Dadhwal, V.K. 2009. Indian forest and tree cover : contributing as a carbon sink (Technical paper), pp. 1-3.

Koller, D. 1972. Environmental control of seed germination. **In** : *Seed Biology*. Vol. **11**. Edition, New York, Academic Press.

Kumar, S., Dhiman, R.C. and Nayital, R.K. 2005. Morphology and biomass parameters of *Pinus roxburghi* Sargent seedlings as affected by container type and growing medium. *Indian Forester* **131**(1) : 37-44.

Lang, A. 1965. Effect of some internal and external conditions on seed germination. *Encyclopedia of Plant Physiology* **15**(2) : 746-803.

Lisowska, K. and Wysokinska, H. 2000. *In vitro* propagation of *Catalpa ovata* G. Don plant cell, tissue and organ culture. *Journal of Biomedical and Life Sciences* **60**(6) : 171-176.

Little, E.L. and Delisle, A.L. 1962. Flowering size, growth rate and life Spain, forest lees, north America. **In** : Altman PL, Dittmer DS, eds, Biological handbook on growth. Washington DC. Federation of American Societies for experimental Biology. Table 103.

Luna, R.K. and Chamoli, N. 2006. Effect of root trainer size on the quality of seedling production in *Albizia procera* (Roxb.) Benth, *Eucalyptus tereticornis* SM and Acacia catechu Wild. *Annals of Forestry* **14**(2) : 184-193.

Maithani, G.S., Beniwal, B.S. and Pyarelal, 1990. Studies on standardization of nursery technique (methods of seed sowing and optimizes 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. *J. Forestry* **38** : 55-60.

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 raised seedlings of deodar and cupressus. *Indian Forester* **122**(8) : 760-762.

Mughal, A.H. and Thapliyal, R.C. 2006. Cones and seed maturity indices in *Cedrus deodara* (D. don, G. don). *Indian Journal of Forestry* **29**(2) : 167-174.

Mumtaz Majeed, Khan, M.A. and Mughal, A.H. 2009. Vegetative propagation of *Aesculus indica* through stem cuttings treated with plant growth regulators. *Journal of Forestry Research* **20**(2) : 171-173.

Ninh, T.P., Wojima, H. and Tashiro, t. 2006. Effect of seed selection based on seed weight and specific gravity on seed germination and seedling emergence and growth in *Angelica acutilosa* Kitagawa. *Japanese Journal of Tropical Agriculture* **50**(3) : 154-162 [cf : CAB Abstracts, 2006].

Nizam, M.Z.U. and Hussain, M.K. 1999. Effect of seed weight on germination and initial seedling growth in *Albizia saman* Jacq. F. Muell. *Indian Forester* **125**(6) : 613-617.

Oliver, W.W. 1974. Seed maturity in white fir and red fir. USDA For. Res. Note INT : 58-17.

Osborne, D.J. 1977. the physiology and biochemistry of seed dormancy and germination (Ed. A.A. Khan). North Holland Publishing Co., Amsterdam, p. 319.

Pandit, A., Pant, K. and Ram, J. 2002. Effect of collection date on capsule moisture content and germination of *P. cilliata* Wall. Ex. Royle from central Himalaya. *New Forests* **23** : 121-130.

Pfister, R.D. 1967. Maturity indices of grand fir cones. *USDA Forest Service Research Paper PSW* **90** : 1-2.

Preising, C.L., Carlson, C.L. and Promnitz, L.C. 1979. Comperative root system morphologies of seeded in place, bare root and containers Doughlas fir seedlings after out planting. *Canadian Journal of Forest Research* **9** : 399-405.

Qaiser, K.N. and Mishra, V.K. 2005. Nursery and field performance of *Acacia catechu* wild. Seedlings raised in different type and size of containers. *Journal of Non-timber Forest Products* **12**(2) : 91-95.

Qurashi, A., Biswas, J. and Mishra, S.K. 1996. Seed height related germination capacity in *Cleistanthus collinus* Benth. *Indian Journal of Forestry* **19**(1) : 79-82.

Sagwal, S.S. 1989. Standardizing the nursery technology of *Robinia pseudoacasia*. *Indian Forester* **115**(11) : 811-815.

Schubert, G.H. and Adams, R.S. 1971. Reforestation practices for conifers in California. State of California Resource agency. Department of Conservation, Division of Forestry, Sacramento.

Sergent, C.S. 1965. Manual of trees and of north America (exclusive of Mexico), 2nd ed., corrected and reported, New York, Dover, p. 934.

Shrivastava, R., Nanhurya, R. and Upadhaya, J.K. 1998. Selection of proper potting mixture for root trainers of Eucalyptus hybrid. *Indian Forester* **124** : 502-510.

Siddique, M.I. and Hussain, S.A. 2007. Effect of indole butyric acid and types of cuttings on root initiation of *Ficus Hawaii*. *Sarhad Journal of Agriculture* **23**(4) : 22-23.

Singh, A. 2006. Status and propagation of hackberry *Celtis* spp. A multipurpose tree species of Kashmir valley. M.Sc thesis submitted to SKUAST-K, Shalimar, pp 37-42.

Singh, O. 1998. Seed maturity indices in silver fir (*Abies pndrow* Spach.). *Indian Forester* **124**(3) : 243-246.

Singh, O. and Kachari, J. 2006. Seed maturity indices in Khari pine (*Pinus kesiya*). *Indian Forester* **132**(12) : 1689-1691.

Singh, V. 1989. Seed maturity indices in spruce. *Indian Forester* **115** : 342-347.

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, D.C., USA, 300-320.

Stokes, P. 1965. Temperature and seed dormancy. *Encyclopedia Plant Physiology* **15**(2) : 746-803.

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

Sutherland, D.C. and Day, R.J. 1998. Container volume effect survival and growth of white sprout, black spruce and jack pine seedlings – a literature review. *North Journal of Applied Forestry* **5** : 185-189.

Tekrony, D.M. and Egli, D.B. 1977. Accumulation of seed vigour development and maturation. **In** : R.H. ellis, M. Black, A.J. Murdoch, T.D. Hong (Eds.). *Basic and Applied Aspects of Seed Biology*, pp. 369-384. Kulwer Academic Publishers, Dordrecht. Great Britain.

Thakur, A., Chowhan, 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.

Troup, R.S. 1921. The silviculture of Indian trees. **III** : 1013-1095. C Paredon Press Oxford.

Upadhayay, L., Singh, R.P., Tewari, A. and Bisht, S. and Shrufi, S. 2006. Seed maturation indications in *Bauhinia retusa* Ham. *Indian Journal of Forestry* **29**(4) : 367-371.

Usher, G. 1974. *A Dictionary of Plants Used by Man*. Constable ISBN 0094579202.

Villiers, T.A. 1974. Seed aging, chromosome stability and extracted viability of seed s… fully imbibed. *Plant Physiology* **53** : 875-878.

Vines, R.A. 1982. Trees, Shrubs and woody vines of southwest Austin : University of Texus Press, p. 1104.

William, R.D. and Hanks, S.H. 1990. Handbook of nursery man's guide. Agric. Handbook, 473. Washington, D.C. USDA Forest Services, p. 78.

Willian, R.L. 1985. A guide to forest seed handling with special reference to the tropics. FAO Forestry Paper 20/2 FAO Rome, p. 379.

Zobel, B. and Talbert, J. 1984. Applied forest tree improvement New York. John Wiley and Sons, p. 605.

ANNEXURE – I

1.	Name	Block	Village	Site

2.	Name of household with parentage	
3.	Total land holding of household	
4.	Income of household from land holdings	
5.	Do you grow catalpa (Yes/No)	
6.	No. of catalpa trees owned	
7.	Type of plantation (Block/Boundary/ Canal)	
8.	Purpose of growing catalpa trees (commercial/household/other)	
9.	Approximate income generated from catalpa	
10.	Any problem in growing catalpa tree?	
11.	Do you want to grow more of these trees?	
12.	Any information pertaining to catalpa during the course of survey	

APPENDIX – I

Occurrence and distribution of *Catalpa bignonioides walt.* in Kashmir valley during 2010-2011

1. Zone A (Srinagar)

In Distric Srinagar (instead of Panchayats, existing wards were taken)

Division	Administrative Zone	Ward Name	Occurrence	No of *Catalpa bignonioides walt.* Trees
Right River Division	East (Zone)	Harwan	+(Dachigam National Park, SKUAST-K, Doodh Mohalla)	4; 3; 1
		Nishat	+(Botanical Garden; Parimahal Road)	16; 7
		Dalgate	+(State Forest Research Institute,Sonwar; Bouleward Road; Gupkar Road);Kashmir Govt. Arts Emporium	2; 3; 2; 2
		Lal Chowk	+(Sheri Kashmir park); M.A.Road	3;7

	North (Zone)	Tarbal	_	-
		Jamia Masjid	+(road leading to SKIMS;Khanyar)	3;2
		Kawadara	_	_
		Hazratbal	+ (Kashmir University)	5
		Tailbal	_	_
		New theed	+	4
		Alusteng	+(FVSC Shuhama)	6
		Soura	+(SKIMS)	8
		Buchpora	+(road)	4
		Safa Kadal`	-	-
	West (Zone)	Idd Gah	+(Iddgah road)	4
		Shaheed Gung	_	_
		Karan Nagar	+	7
		Qammerwari	_	_
		Chattabal	_	_
		Bemina	+(BOSE;womens poly technic)	2;2
		Batmaloo	_	_

		Nundrash Colony	–	–
Left River Division	South (Zone)	Rajbagh	+(Near Silk Weaving Showroom)	3
		Jawahir Nagar	+	4
		Wazirbagh	+(Road)	3
		Amarsingh college	+(Campus)	11
		Natipora	–	–
		Chanapora	–	–
		Baghat Barzulla	+(Bund)	2
		Rawalpora	+(road)	6
		Parray pora	+(road)	4
		Humhama	+(Air port road)	5

+ = **Found**

- = **Not found**

Occurrence and distribution of *Catalpa bignonioides walt.* in Kashmir valley during 2010-2011

b	Ganderbal	1Ganderbal 2 Lar 3 Kangan 4 Wakura	1 Ganderbal (100 %)	20	. Nuner	1. Nuner proper 2. Bobsipora 3. kawbal 4. Chapargund	- – - –	
					2. Tulamulla	1. Tulmulla proper 2. Dangerpora 3. Boghu Rampora 4. Ladwana	–	
					3. Serch	1. Serch Bala 2. Dadkanth 3. Serch payeen 4. Merdabagh	–	
					4. Harran	1. Harran 2. Tehlipoa 3. Gund rehman 4. Khann	–	–
			2. Lar	21	1. Lar	1. Lar a 2. Ranbir bagh 3. Repora 4. Lar b	– – – –	
					2. Manigam	1. Manigam a 2. Arhama 3. Yarmuqam 4. Manigam b	– – – –	

			B		3 Chuntwaliwar	1 Chuntwaliwar a 2 Chuntwaliwar b 3 Chuntwaliwar c 4 Chuntwaliwar d	– 	–
					4. Haripora	1. Haripora proper 2. Dursum 3. Bonezul 4. Gujarpati	 – – – –	
			3 Kangan	43	1. Kangan	1. Kangan 2. Panzin 3. Kichpora 4. Margund	 – – –	
					2. Wangath	1. Wangat 2. Katiwangat 3. Narannag 4. Pahalnar	– – – –	
					3. Wussan	1. Wussan proper 2. Bela wassan 3. Managam 4. Preng	 – 	 –
					4. Sonamarg	1. Sonamarg proper 2. Sarbal 3. Nilgrar 4. Gaganger	– – – –	

			4. Wakoora	19	1 Wakura	1 Wakura a 2. Wakura b 3.Wakura c	– – –	
					2 Dub	1. Gamwara 2. Dub 3. Malik Mohallah 4. Shalahar	––	–
					3 Safapora	1 Sehpora 2 Shallabugh 3 Chendena 4 Drarbal	– – – –	
					4.Sehpora	1 Sehpora a 2 Hatbura 3 Mujgund 4 Sehpora b	––	
3	Budgam	1. Budgam 2. Khag 3. Narbal 4. Khan sahib 5. Beerwah 6. Chadora 7. B.K. Pora 8. Nagam	1 B.K. Pora(50%)	27	1. Kanipora	1. Wani Mohalla 2. Mir Mohalla 3. Saidapora 4 Beigh Mohalla	– – +	1
					2. Wagoora	1. Harpora 2. Eidgah Mohalla 3. Pandaw Mohalla 4. Mukdam Mohalla	––	
					3. Pahroo_A	1. Shah Mohalla 2. Gooripora 3. Ganaie Mohalla 4. Kabu Mohalla	––	

					4. Pahroo-B	1. Pahroo Check 2. Rather Mohalla 3. Dar Mohalla 4. Mohalla Sadiq Bhat	– 	
			2. Chadoora	40	1. Surasyar	1. Nengar Mohalla 2. Mir Mohalla 3. Dar Mohalla 4. Mir Mohalla	+ – – –	2
					2.Sogam	1. Sogam 2 Mohinoor 3. Kraliwari 4.Gund	+ – – –	1
					3. Gowherpora	1. Nadandhar 2. Kuzweera 3. Gowerpora Main 4. Khanpora	– 	
					4.Panzan	1. Bonpora 2. Harpora 3. Mirpora 4. Gooripora	– – – +	1
			3. Khan sahib	50	1. Arigam	1. Arigam 2. Mujpathri 3. Doodpathri 4. Lalagam	– – + –	2

					2. Raithan	1. Raithan 2. Bugroo 3. Wudwan 4. Narkura	+ – + -	3 1
					3. Watterhail	1. Watterhail 2. Gund Ali Naik 3. Hardawail 4. Brail	 –	
					4. Rawalpora	1. Rawalpora 2. Kralnewa 3. Parpora 4. Khospora	 –	
			4. Nagam	38	1. Nagam	1Babawani 2. Harpora 3. Khosa Mohalla 4. Ada Mohalla	+ - - -	3
					2. Nowpora	1. Shah Mohalla 2. Mukdumpora 3. Gooripora 4. Harpora	 –	
					3. Hafroo	1. Hafroo 2. Batpora 3. Loolipora 4. Humpora	 – + – –	2

					4. Hayatpora	1. Kaka Mohalla 2. Doonilab 3. Hakpora 4. Pal Mohalla	 –	
Zone C – South Kashmir (Anantnag, Kulgam, Pulwama, Shopian)								
4.	Anantnag	1. Shahabad 2. Achabal 3. Shangus 4. Qazigund 5. Breng 6.Khoveripora 7. Dachnipara	1 Dachnipora	43	1. Kanelwan	1. Banpora 2. KarlooA 3. KarlooB 4. Tantraypora	+ + – –	5 4
					2. Srigufwara	1. Widhaii 2. Benpora 3. Herpora 4. Mukhdompora	– + -	3
					3. Bijbehara	1. DaraShikoh garden,Zirpora 2. New coloney 3. Devan bagh 4. Jablipora	+– – –	2
					4. Awoora	1.Janderpati(awoora) 2. Herpora 3. Kralpora 4. Bungam	 –	–
			2. Shangus	31	1. Chattergul	1.Mantipora 2.Tengimula 3.Gawran 4. Kharpora	+ – – -	2

					2.Dethoo	Dethoo a Dethoo b Ahu Passian Cheripora	–	
					3. Nowgam	1.Nowgam a 2. Nowgam b 3. Andu 4. Khundru	–	
					4. Watersoo	1. Khanpora 2. Bassan 3. Brariangan	_	
			3. Shahabad	34	1. Brawgam	1. Mohmoodabad 2. Gund 3. Qundarpora 4. Bunpora	–	
					2. Kredimowpora	1. Kredi (A) 2. Gunde Umar 3. Nowpora 4. Kredi (B)	+	2
					3. Verinag	1. Chuntpur 2. Gurnar 3. Gani gund 4. Malikpur	+ +	4 6
					4. Larkipora	1. Fattehpur gund 2. Naidpora 3. Lukubhawan 4. Larkipora	-	-

				34	1. Akingama	1. Bonpora 2.Harpora 3.Badooda 4. Akingam Main	– +	2
					2. Achabal	1. Cheki-achabal 2. Khunduru 3. Jagi-gund 4. Achabal	- + -	3
					3. Imoh	1. Thoker Chekh 2. Baghawad 3. Gorghor Check	–	
					4Tailwani	1. Tailwani-A 2. Tailwani-B 3. Tailwani-C 4. Tumberpora	–	
5.	Kulgam	1.Qaimoh 2.Pahloo 3 D.H Pora 4 Devsar 5 Kulgam	1 Qaimoh(80%)	23	1. Redwani	1. Hovur 2. Mushpoor 3. Kawdaran 4. Wadipora	–	
					2. Rampora	1.Brazloo 2. Nai Basti 3.Alamdar Colony 4. Gufbal	+	2
					3. Mathalhama	1. Chadder 2. Naidpora 3.Gratabal 4. T Nowpora	–	

					4. Danew	1Sheikhpora 2. Wani Mohalla 3. Kanikhair	–	–
			2. Kulgam	33	. Poniwah	1. Lonchkhrewan 2. Mahagund 3. Mah	-	
					2.Nanibugh	Nanibug Main 2. Yemrech 3. Yaripora	–	
					3.Nillow	1 Nillow a 2. Nillow b	_	
					4. Amnoo	1. Amno-A 2.Amno-B 3. Brazloo 4. Aishmuji	–	
			3. Devsar	33	1. Kilam	1. Kilam a 2. Kilam b 3.Chanpora 4. Parraypora	–	
					2. Akhran	1. Akhran Main 2. Mir Bazar 3. Nowpora	_	
					3. Chowgam	1.Chowgam a 2. Chowgam b 3. Khargund	_	

					4.Khudwani	1.Khudwani a 2. Khudwani b 3. Rahpora 4. Gangipora	– 	
			4 D. H .Pora	53	1.Nandimarg	1.Nandimarg a 2 Nandimarg b	–	
					2 Yarikah	1 Yarikah a 2. Yarikah b 3. Yarikah c	– 	–
					3.D.K Marg	1. .D.K Marg a 2. .D.K Marg b 3. .D.K Marg c	– 	
					4 Chimer	1.Chimer a 2.Chimer b	 –	
6.	Pulwama	1. Tral 2. Kakapora 3. Keller 4. Pulwama 5. Pampore	1Kakapora (80.00 %)	29	1. Newa	1. Zadoora 2. Newa 3. Wahubug 4. Gudoora	 + +	 2 1
					2. Pinglina	1. Pinglina 2. Pathan 3. Tenabona 4. Gund	+	1
					3. Lajoora	1. Kail 2. Pushal 3. Lajoora a 4. Lajoora b	 –	

					4. Kakapora	1. Kakapora 2. Bandipora 3. Sanbura 4. Lalahar	+ –	2
			2. Keller	29	1. Rajpora	1. Bellow 2. Rajpora 3. QasbiYar 4.Batmadan	– + +	 1 4
					2. Rahmoo	1. Rahmoo 2. Ghoosu 3. Tujan 4. Mitergam	 – +	 1
					3. Drabgam	1. Drabgam a 2. Drabgam b 3. Akhal 4. Sheikhard	 –	
					4. Abhama	1. Abhama Main 2. Sangerwani 3. Bagh Sangerwani 4. Chewan	 + –	 3
			3. Pulwama	45	. Tengpona	1Tengpona 2. Mugulpora 3. Harpora. 4. Bonpora	 –	

					2.Payer	1. Payer Main 2. Tenghar 3. Takiya Payer 4.Asthanpora	–	
					3. Malangpora	1. Malangpora 2. Ranzipora 3.Gulzarpora 4. Padgampora		2
					4. Boonera	1.Boonera 2.Bandzoo 3.Jandwal 4.Rajmahal	– + -	3
			4 Tral	60	1 Midoora	1. Midoora_A 2. Midoora-B 3. Khangund 4. Khankha	–	–
					2. Nawdal	1. Har Nawdal 2. Bon Nawdal 3. Wanipath 4. Bulley	+	3
					3.Batagund	1. Gulshanpora 2. Takia	–	
					4.Shahabad	1. Har Shahabad 2. Bon Shahabad	+	2

7	Shopian	1.Shopian 2.Keller	1 Shopian (100 %)	74	1. Heff	1. Heff 2. Shirmal 3. Ganai Mohallah 4. Dar Mohalla	–	
					2. Momander	1. Shahloot 2. Chanpora 3. Nadwaw 4. Momander	–	
					3. Pinjoora	1. Pinjoora 2. Pahnoo 3. Guglud 4. Sofarnaman	-	
					4. Saidpora	1. Saidpora Bala 2. Saidpora Payeen 3. Chek 4. Amshipora	-	
			2. Keller	29	1.Barthipora	1.Berthipora a 2.Berthipora b	-	
					2.Manloo	1.Manloo a 2.Manloo b	–	
					3.Zawoora	1.Zawoora a 2. Zawoora b		
					4.Pehlipora	1.Pehlipora a 2.Pehlipora b	–	

Zone -A North Kashmir (Baramulla, Kupwara and Bandipora)								
8.	Baramulla	1. Singh Pora 2. Kunzer 3. Rafiabad 4. Baramulla 5. Wagoora 6. Pattan 7. Tangmarg 8. Uri 9. Boniyar 10. Sopore 11. Zaingeer 12. Rohama	Baramulla	38	. Main Baramulla	2. Azad Gunj 3. Noorbagh 4. Kant Bagh 5. Khwajabagh	 + +	15 4 3
					2. Binner-A	1. Janbazpora 2. Venkari 3. Umer Colony	+ 	3 1
					3. Delina	1. Jahama 2. Kanispora 3. Delina Gat	 +	– 2
					4. Shutloo	1. Vohlutra 2. Kamar 3. Brehman 4. Lariangan	 –	
			2. Zaingeer	38	1. Watlab	1. Watlab 2. Ghat 3. Magraypora 4. Hatlangu		
					2. Shiva	1. Harshiva 2. Bonshiva		
					3. Bomai	1. Hedipora 2. Bomai 3. Wadura 4. Lageripora	 +	 3

					4. Seloo	1. Seloo proper 2. Mirpora 3. Dugpora	–	
			3.Rafiabad	22	1. Nadihal	1. Ladoora 2.Sadipora 3.Nowgam 4. Chakgogri	–	
					2. Dangiwacha	1.Batsuma 2.Renan 3.Chenam 4.Chatoosa	–	
					3.Saripara	1. Chijhama 2. Beden 3. Hadipora 4.Ferozpora	-	-
					4. Watergam	1. Watergam main 2.Behrapora 3. Pazalpora 4.Yarbugh	+ –	2
			4. Pattan	36	1. Pattan	1. Zangam 2. Rembal 3. Pattan proper 4. Bhat Mohallah	+	1
					2. Shirpora	1. Hardrath 2. Khanapeth 3. Mirpur 4. Khespore	–	

					3. Nolur	1. Sherabad 2. Nolur proper 3. Kakavpora 4. Kungumdara	–	–
					4. Wanigambala	1. Wanigambala (A) 2. Wanigambala (B) 3. Tilgam 4. Syed Mohalla	+	1
1.Bandipora (80 %)	Bandipora	1. Bandipora 2.Tulail 3 Gurez 4 Hajin 5.Sumbal Contd…		50	1. Aloosa	1. Aloosa proper 2. Malangam 3. Budipora main 4. Potpora	–	
					2. Quil Muqam	1. Quil 2. Kema 3. Mangnipora 4. Muqam	–	
					3. Ashtangoo	1. Ashtangoo 2. Kanibacha 3. Quinisa 4. Paribti	–	
					4. Bonkote	1. Bonkote 2. Chiternaar 3. Aathwatoo 4. Ahan Sharief	+	4

			2.Hajin	28	1.Baharabad-A	1.Kathpora 2. Chakpora 3. Waskundal 4. Baharpora	-	-
					2.Baharabad-B	1.Khumena 2.Hanjipora 3.Ganaie Mohalla 4. Tengpora	+ +	1 1
					3.Vijpara	1. Bunpora 2. Mukumpora 3. Manzpora	–	–
					4.Markundal	1. Markundal Main 2. Gulshanpora 3. Tengpora 4. Maidan Mohalla	–	
			3. Sumbal	16	1.Main Sumbal	1. Main Sumbal 2. Inderkoot 3. Bata Mohalla 4. Wangipora	–	
					2.Asham-A	1. Sofipora 2. Khan Mohalla 3. Shah Mohalla 4. Parray Mohalla	–	

					3. Asham-B	1. Ganaie Mohalla 2. Dangerpora 3. Rather Mohalla 4. Hanji Mohalla	–	
					4. Nesbal	1. Reishpora 2. Manzpora 3. Wagay Mohalla 4. Pethpora	+	2
10	Kupwara	1. Langate 2. Rajwar 3. Sogam 4. Kupwara 5. Trehgam 6. Kralpora 7. Ramhal 8. Tanghda 9 Kalaroos 10Wavoora 11Teetwal	1.Langate	52	1. Mawar	1.Haril 2. Hangah 3. Kalamabad 4. Sherhama	–	
					2. Lach	1. Shahnegri 2. Kutlari 3.Drungsoo	–	–
					3. Kalamchakala	1. Audora 2.Check Audora 3. Warpora	–	
					4. Panditpora	1.Hampora 2.Nehama 3.Wadipora	–	
			2. Trehgam	34	1. Gugloosa	1. Lone pora 2. Gogloosa a 3. Gogloosa b 4. Chowbarpora	–	

					2. Gulgam	1. Gulgam a 2. Bandi Mohallah 3. Batargam 4. Gulgam b	–	
					3. Herrii	1. Qadirabad 2. Laderwan 3. Hund 4. Kawari	–	
					4. Trehgam	1.Trehgam a 2. Trehgam b 3. Trehgam c 4. Trehgam d	–	
			3. Sogam	27	1. Sogam	1. Sogam a 2. Sogam b 3. Wanipora 4. Mir Mohallah	–	–
					2. Diver	1.Diver a 2.Diver b 3. Diver c 4. Diver d	–	–
					3. Lalpora	1. Kanthipora 2. Lalpora a 3. Lalpora b 4. Shalgund	–	

					4. Dardpora	1. Dardpora 2. Lalapora 3. Krusin 4. Siwan	–	
			4. Kupwara	56	1. Kandi	1 Kandi a 2. Kandi b 3. Dudwan 4. Mir Mohallah	–	
					2. Drugmulla	1. Drugmulla 2. Muqam Shehuali 3. Bumhuma 4. Waterkhani	–	
					3. Mugalpora	1. Mugalpora 2. Kadihama 3. Dadikuta 4. Punzua	–	
					4. Nutnoosa	1.Nutnoosa a 2. Nutnoosa b 3. Mirnag 4. Manigah	–	–

APPENDIX – II

Analysis of Variance for Germination Percentage

Source	d.f.	S.S	MSS	F	Pr(>F)
Replications	6	95.62	15.94	0.8916	0.5306
Treatment	2	2249.88	1124.94	62.93	4.348e-07
Residuals	12	214.50	17.88		
Total	20	2560			

Analysis of Variance for Survival Percentage

Source	d.f.	S.S	MSS	F	Pr(>F)
Replications	6	34.33	5.72	0.5084	0.791
Treatment	2	1952.74	976.37	86.76	7.32e-08
Residuals	12	135.03	11.25		
Total	20	2122.1			

Analysis of Variance for Shoot Height

Source	d.f.	S.S	MSS	F	Pr(>F)
Replications	6	132.82	22.14	1.932	0.1578
Treatment	2	854.13	427.07	37.1025	7.276e-06
Residuals	12	138.13	11.51		
Total	20	1125.08			

Analysis of Variance for Root Length

Source	d.f.	S.S	MSS	F	Pr(>F)
Replications	6	37.20	6.20	0.4873	0.8059
Treatment	2	647.70	323.85	25.453	4.818e-05
Residuals	12	152.68	12.72		
Total	20	837.58			

Analysis of Variance for Collar Diameter

Source	d.f.	S.S	MSS	F	Pr(>F)
Replications	6	0.4151	0.0692	0.3807	0.8776
Treatment	2	20.721	10.361	57.01	7.45e-07
Residuals	12	2.18	0.1817		
Total	20	23.31			

Analysis of Variance for Root Shoot Ratio

Source	d.f.	S.S	MSS	F	Pr(>F)
Replications	6	0.238	0.00397	1.0922	0.42018
Treatment	2	0.0372	0.01861	5.1109	0.02480
Residuals	12	0.0437	0.00364		
Total	20	0.1047			

Analysis of Variance for Sprouting Percentage

Source	d.f.	S.S	MSS	F	Pr(>F)
Treatment	6	87.879	14.6465	9.2033	0.000379
Residuals	14	22.280	1.5914		
Total	20	110.15			

Analysis of Variance for Survival Percentage

Source	d.f.	S.S	MSS	F	Pr(>F)
Treatment	6	80.350	13.3917	31.974	2.144e-07
Residuals	14	5.864	0.4188		
Total	20	86.214			

Analysis of Variance for Diameter of Leading Shoot

Source	d.f.	S.S	MSS	F	Pr(>F)
Treatment	6	11.3116	1.88525	29.585	3.520e-07
Residuals	14	0.8921	0.06372		
Total	20	12.2031			

Analysis of Variance for No. of Roots/Cutting

Source	d.f.	S.S	MSS	F	Pr(>F)
Treatment	6	83247	13874.50	11.731	9.104e-05
Residuals	14	16558	1182.7		
Total	20	99805			

Analysis of Variance for Length of Longest Root

Source	d.f.	S.S	MSS	F	Pr(>F)
Treatment	6	266.228	44.371	21.278	2.766e-06
Residuals	14	29.195	2.085		
Total	20	295.42			

Analysis of Variance for Effect of Different Treatments on Germination

Source	d.f.	S.S	MSS	F	Pr(>F)
Replication	3	28.63			
Treatments	1	14.97	14.97	1.35	0.32
Error	3	33.25	11.88		
Total	7	76.84			

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CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner Dr. M.S. Malik, Chairman, Department of Silviculture and Agroforestry, Faculty of Forestry, BAU, Kanke, Ranchi during Viva-Voce examination held on 04-01-2012 have been incorporated in the manuscript entitled **"Status and Propagation of Indian Bean Tree (*Catalpa bignonioides* Walt.) in Kashmir Valley"** submitted by **Mr. Rafiq Ahmad Mir (Regd. No. 2009-For-26-M).**

(Dr. P.A. Sofi)
Chairman
Advisory Committee