

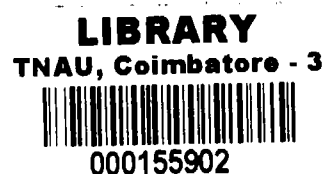
**INVESTIGATIONS ON SEED SOURCE VARIATIONS,
STANDARDIZATION OF SEED TESTING PROCEDURES AND
NURSERY TECHNIQUES IN *Albizia lebbek* (L.) Benth.**

Thesis submitted in part fulfilment of the requirements for the degree of
**DOCTOR OF PHILOSOPHY (AGRICULTURE) in SEED SCIENCE AND
TECHNOLOGY** to the **TAMIL NADU AGRICULTURAL
UNIVERSITY, COIMBATORE**

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1999

CERTIFICATE

This is to certify that the thesis entitled "INVESTIGATIONS ON SEED SOURCE VARIATIONS, STANDARDIZATION OF SEED TESTING PROCEDURES AND NURSERY TECHNIQUES IN *Albizia lebbek* (L.) Benth." submitted in part fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY (AGRICULTURE) in SEED SCIENCE AND TECHNOLOGY to the Tamil Nadu Agricultural University, Coimbatore is a record of *bonafide* research work carried out by Mr. S. NATARAJAN under my supervision and guidance and that no part of this thesis has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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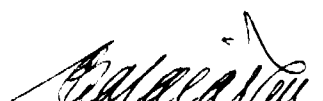
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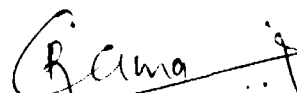
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ACKNOWLEDGEMENT



ACKNOWLEDGEMENT

I feel immense pleasure in extending my heartfelt gratitude to **Dr. K. Vanangamudi**, Professor of Seed Science and Technology, Forest College and Research Institute, Mettupalayam and Chairman of the Advisory Committee for his unsolicited guidance, valuable suggestions and help rendered throughout the study period and critical evaluation of the entire thesis.

I extend my sincere thanks to the members of the Advisory Committee, **Dr. S. Natarajan**, Professor and Head, Horticultural Research Station, Vijayanagaram, **Dr. V. Palanisamy**, Associate Professor of Seed Science and Technology and **Thiru. K.T. Parthiban**, Assistant Professor of Forestry and **Mrs. R. Umarani**, Assistant Professor of Seed Science and Technology, Forest College and Research Institute, Mettupalayam for their helpful suggestions and guidance in carrying out the study.

I am extremely thankful to **Dr. V. Krishnasamy**, Professor and Head, Department of Seed Science and Technology, for his valuable suggestions. I am indebted to **Prof. S. Balaji**, IFS., Dean (Forestry) and **Dr. K. Vanangamudi**, Principal Investigator of the GOI-ICFRE Project on Forest Tree Seed Technology for providing the Research Assistantship for doing my degree. I am also thankful to **Dr. C. Surendran**, Professor and Head, Department of Tree breeding for his kind help and Co-operation.

I express very sincere thanks to my friend **A. Venkatesh, Ph.D.**, Scholar in Forestry for his boundless help and co-operation in shaping the thesis and also to **Dr. (Mrs.) Mallika Vannagamudi**, Assistant Professor of Crop Physiology for her suggestions and hospitality

I consider it as a privilege to place on record my gratitude to **Dr. V. Valluvaparidasan**, Associate Professor of Seed Pathology, **A. Bharathi** Assistant Professor of Seed Science and Technology **Dr. Md. Yassin** Assistant Professor

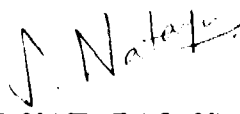
of Agronomy, **I. Sekar**, Assistant Professors of Forestry and the staff of the Department of Seed Science and Technology for their help at various instances.

I thank my classmates and well wishers **Mrs. D. Neelamathi, Rajkumar, Ramesh Babu, Prabakaran** and **Ramesh** for their constant encouragement and moral support. I also thank my Junior friends, **Mani, Rajendrakumar, Muruganandham, Balaji, Radha**, and **other friends**. I wish to thank **Viji, Ganeshamoorthy** and **Rukumani** for their help in laboratory studies.

I owe my sincere dedication to my beloved parents, brother, sister and dear pets.

I am always grateful to the Alma matter, TNAU for shaping my life and made my stay here a memorable one.

Sincere thanks to **Mr. V. Kannan, Miss. S. Sasi**, and **Miss. K. Kalpana** of *M/S Priyal's Computers*, Coimbatore – 41 for the excellent typing of this thesis.


(S. NATARAJAN)

Please read

Albizia lebbek

as

Albizia lebbeck

ABSTRACT

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INVESTIGATIONS ON SEED SOURCE VARIATIONS, STANDARDIZATION OF SEED TESTING PROCEDURES AND NURSERY TECHNIQUES IN *Albizia lebbek* (L.) Benth.

By

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1999

Studies were undertaken on vagai (*Albizia lebbek* (L.) Benth.) to identify the best seed source for seed collection, standardization of seed testing procedures and development of nursery technologies for quality seedling production.

A study conducted to delineate the seed source variation indicated that Anamalai Wild Life Sanctuary (WLS) and Coimbatore of Western zone possessed superior CPTs for collection of seeds. The seeds collected from Coimbatore recorded more seed breadth and weight. While the seeds from Tirunelveli (Southern zone) and Anamalai WLS (Western zone) registered the highest germination of 94.0 and 91.0 per cent respectively. When outplanted in the field, the seed sources such as Coimbatore, Mettupalayam, Aliyar and Erode of Western zone outperformed others with respect to survival and establishment.

Investigations on standardization of seed testing procedures revealed that the weight of working sample is 276 g. The weight of submitted sample is arrived as 2762, but

subjected to a maximum of 1000 g (ISTA, 1993) the weight of submitted sample is reported as 1000 g. The weight of hundred seed is 10.776 g. The seed lot should possess a minimum purity of 99 per cent.

While conducting germination test, the seeds should be given pretreatment with either sulphuric acid scarification for 25 min. or acid scarification followed by IAA 200 ppm soaking for 24 h. GA₃ 100 ppm infusion for 12 h to break seed dormancy. Sand medium could be recommended for conducting germination test.

For conducting quick viability (tetrazolium) test, the seeds should be preconditioned by nipping off the seed coat followed by 24 h water soaking. The best suited preparation method was longitudinal splitting of cotyledons. A concentration of one per cent tetrazolium solution was found optimum for proper staining to facilitate effective separation of viable and non-viable seeds.

To evaluate the vigour status of seed lot, the vigour tests such as NaCl at 0.75 %, pH at 8, PEG at 1.25 % and accelerated aging for 8 days could be suggested.

In seed health testing, the blotter medium was more effective than agar medium to find out the presence of seed borne pathogens.

The nursery experiments on the development of technologies for elite seedling production showed that the seedlings grown in big container (15 x 25 cm polybag) and larger volume root trainer (600 cc) produced vigorous and quality seedlings. The potting mixture containing red soil:sand:goat manure followed by red soil:sand:vermicompost gave higher germination and more vigorous seedlings. The tallest height class (61-75 cm) and biggest diameter class (0.51-0.61 cm) should be chosen for outplanting purposes.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Albizia lebbek commonly called as Vagai or Siris belongs to the family Mimosaceae. It is a nitrogen fixing, semi deciduous tree species, widely planted as avenue tree and in gardens.

It has variety of purposes like the leaves and twigs are excellent fodder for camels and other cattle. The seasoned timber is hard and durable with a specific gravity of 0.800. It can be used for high class furniture, interior decoration, naves of wheels, parts of boat, panneling, railway carriage work, vehicle bodies, agricultural and other implements for structural purposes. It is also used as an excellent source of fuel and charcoal (Webb *et al.*, 1980), jaggery mould, gum from the barks etc., Due to its wide adaptation, it is a popular species for reforestation, fuelwood plantation and agroforestry development world wide. (Venkataramany, 1968; Webb *et al.*, 1980; Parrotta, 1987).

The demand for the tree seeds has increased a 1000 fold in the last decade. While extending the planting of *A. lebbek* trees under various social forestry, agroforestry projects etc., large quantity of good quality seeds and seedlings are needed.

The use of sound seed from stands of high inherent quality is widely recognized as the best means of ensuring fast growing and healthy plantations capable of yielding high quality wood (Aldhous, 1972). The multiplication and distribution of quality seeds or seedlings is of immediate need so as to achieve a breakthrough in these programmes. For tree planting programmes, larger quantities of seeds are to be produced and tested for germination and seedling vigour.

Prior to seed testing and certification, more emphasis should be made to delineate seed source variations and to identify the best seed source for the collection of good quality seeds and subsequent production of high quality planting material. The variations in seeds were reported on many tree species and the variation is dictated by environmental factors. This may be due to altitudinal variation as reported by Barnett and Farmer (1978) in yellow poplar (*Populus* sp.) or region of collection (Bonner, 1984). Hence, best provenance has to be selected to screen the natural and environmental variations and to choose the best available sources for seed collection.

The physical characteristics of the seeds collected from various sources show polymorphism for its physical measurements and its weight. The physical measurements finds importance as they have an indirect bearing on seed quality. Seeds of almost all tree species are prone to be attacked by various insects, fungi and bacteria while they are in the tree itself (Bedell, 1989). The insect damage affects the seed germination in *A. lebbek* (Ponnuswamy *et al.*, 1990). Satya Vir and Jindal (1997) also reported 48, 46 and 20 per cent insect damage in *Prosopis cineraria*, *A. lebbek* and *Acacia senegal*. Assessment of the damage caused by the insects will be helpful in calculating the seed rate required for raising the plantations.

It is essential to evaluate the performance of different seed sources under nursery conditions to study the provenance effect and for further selection of best suited provenance. Similarly, outplanting in field is also important to know the survival potential of sources.

In order to improve the rural economy in the arid and semi-arid regions and achieve successful tree growth in the problem soil areas, viz., saline, acidic, alkaline and in

drought prone areas, it is essential to know the higher tolerance of species towards salinity, acidic and alkalinity stresses.

For tree planting programmes, large quantities of seeds are needed, which have to be tested and certified for optimum germination and seedling vigour. The International Seed Testing Association (1993) had standardized and prescribed rules for some tree species, mostly temperate species and the information available was not comprehensive. Moreover, it lacks information for the seed testing standards and procedures standardized to our tropical conditions. Seed certification in forestry is different from that of the certification in agriculture where generation systems are followed. In forestry, certificate may be issued for seeds from Seed Production Areas (SPA) and plus trees. Standardization of seed testing has to be done on a large number of seed lots.

The aim of seed testing in forestry is to assess the value of a seed lot with regard to the number of germinable seeds in the lot. This helps to determine the quantity of seeds required per unit area of the nursery bed. Hence, the standardization is important for the weight of submitted and working sample size, purity analysis, seed weight, germination medium, tetrazolium test and seed health testing.

As a seed testing procedure, standardization of submitted and working sample size is important so as to have a true representation of the bulk seed lot and to maintain the uniformity for submission of seeds. The purity test is significant as this factor affects the number per unit weight of genuine seeds and the germination per cent of the seed lot (ISTA, 1993).

To get uniform results during seed testing, seed dormancy has to be overcome and higher germination potential has to be realized through pre-treatments. Hard seeds in

leguminous plants have been attributed to total genetic and environmental factors (Donnelly, 1970). Hard seedness or impermeability of the seed coat may inhibit germination. As *A. lebbek* is also a leguminous species, pre-treatments is essential. Several researchers have demonstrated the use of growth regulators (Ballantyne, 1991) to enhance germination and to produce vigorous seedlings in many tree species.

For conducting germination test in the laboratory, standardization of germination medium is to be done before recommending for adoption. The medium used must be non-toxic to the germinating seedlings and must provide adequate aeration and moisture.

The viability of the seeds can be standardized with the use of 2, 3, 5 - triphenyl tetrazolium chloride in shorter period of time. Tetrazolium staining is a dependable and accepted biochemical method for testing the inherent germination of a seed lot. This is especially important in forest seeds which take much longer time to germinate or may exhibit varying types of dormancy.

The capacity for production of healthy seedlings is measured as germination response under environmental conditions which impose one or more elements of stress on the seed normally encountered in the field. Accordingly, standardization of a suitable vigour test is indispensable to test the suitability of the seeds sample to any particular stress condition viz., salinity, alkalinity, acidity, drought etc.,

The supply of good quality planting stock is of prime importance. Hence, Standardization of a suitable nursery technology is a must. Containers are increasingly used to improve outplanting survival and minimize transplanting shock. Containers have passed through a number of evolutionary shapes and designs. With the advancement in forestry, though polybags are commonly used, of late, root trainers are substituted for

polybags. The potting mixture is also important to obtain better seedlings. The establishment and survival of the planting stock in the field are mainly dependent on the production of good quality planting stock which is again controlled by several external factors like seedling grade viz., height and diameter.

Against these backdrops, investigations were carried out with the following objectives.

- ☆ to select the Candidate Plus Trees (CPTs) in different agroclimatic zones for seed collection.
- ☆ to find out the effect of seed source on seed physical and physiological parameters under nursery and field conditions for the production of high quality seedlings.
- ☆ to standardize the submitted and working sample size, purity analysis, seed weight, pre-treatments to break dormancy and germination medium.
- ☆ to standardize the quick viability (Tetrazolium) test viz., method of preconditioning, preparation and concentration of tetrazolium solutions.
- ☆ to standardize the various physiological vigour tests viz., NaCl salt stress, pH, Poly Ethylene Glycol (PEG) and accelerated aging test.
- ☆ to standardize the seed health testing
- ☆ to develop the nursery technologies for elite seedling production.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The available literatures pertaining to studies on seed source, seed testing procedures which include germination requirements (pre-treatments for breaking dormancy and germination medium), tetrazolium test, vigour test and seed health testing and nursery technologies for quality seedling production have been reviewed and presented herein.

2.1. EFFECT OF SEED SOURCE ON SEED QUALITY

Agroecological conditions largely comprising of edaphic and environmental factors have more than one effect on the performance of the seeds. The possibility is that seeds are also influenced by memories of their place of birth (Heydecker, 1972).

According to Murthy (1973), there was a large variation in seed size and weight among the tested provenances in teak.

Gupta and Pattanath (1975) stated that greater variations were noticed in germination capacity of teak seeds collected from 18 different sources in India.

Deodar (*Cedrus deodora*) collected from six different sources indicated variation with intensity of dormancy. The percentage of germination without stratification varied from 16-68 per cent in different seed lots (Thapliyal and Gupta, 1980).

Joshi *et al.* (1983) tested seed weight and germination in provenances. The germination percentage of *Acacias* varied widely among the locations. Seeds from Midnapur of West Bengal which recorded maximum germination of 96.6 per cent.

Seeds from 8 selected sandal trees recorded germination percentage ranging from 25-61 per cent and showed significant differences among the trees (Bagchi and Kulkarni, 1985).

Ezumah (1986) conducted the germination test on neem seeds collected from different locations of Ethiopia and did not find significant differences among the seed lots tested.

Prasad and Jalil (1986) reported that wide variation existed in germination percentage in teak drupes collected from two different provenances which differs in size and weight within and between seed lots.

Significant variation between provenances was found in survival percentage, height, wood basic density and diameter at breast height in *Acacia mangium* (Pipatwattanakul, 1989).

Bagchi and Sharma (1989) obtained significant variations in seed weight among the seed samples of sandal collected from various locations.

Seeds of *Albizia falcataria* from the Philippines provenance significantly showed better germination and seedling vigour than the Malaysian provenance (Bahuguna *et al.*, 1989).

The results of Bedell (1989) showed that teak drupes from 36 Indian provenances differed for their pre-treatment required for enhancing the germination.

According to Dasappa (1990), teak seeds collected from different regions exhibited wide variations in seed size, shape and germination behaviour.

Jambulingam (1990) observed that seeds of *Casuarina equisetifolia* collected from riverine source was superior in germination and seedling height compared to the inland and coastal seed sources.

Seedling growth parameters except height were significantly different between the 12 seed lots of *Santalum album* (11 from Karnataka and 1 from Tamil Nadu). One of the Karnataka seed lot showed more seedling vigour (452) compared to other seed lots (Veerendra and Sarma, 1990).

Kumaran (1991) reported that the seed source variation in respect of seed length and breadth and its ratio, hundred seed weight and oil content in neem.

Sivasamy (1991) reported the impact of seed source variations in seed germinability, vigour and biochemical composition in neem. He also reported that pungam seeds collected from different sources recorded greater variation for seed size and seed shape.

Anon (1992) reported a wide range of variations in the seeds of *Acacia nilotica* collected from different sources.

Seeds of *Cassia siamea* collected from Coimbatore recorded maximum 1000 seed weight, germination and seedling vigour, while Tirupur proved better for *Prosopis juliflora* with maximum 1000 seed weight (Masilamani, 1992).

Dwivedi (1993a) observed a wide variation in the germination of neem seeds collected from different provenances in India.

A significant difference among places of seed collection was recorded for seed weight, seedling growth and biomass in *Acacia nilotica* (Suresh, 1994).

Bangarwa *et al.* (1995) observed significant differences in germination between the progenies of different locations, whereas progenies from the same location showed non-significant differences.

Ginwal *et al.* (1995) reported that significant variation was observed in seed germination pattern of five sub species of *Acacia nilotica* belonging to 30 provenances when studied under nursery conditions.

Seeds of *Azadirachta indica* collected from different places in Karnataka and Andhra Pradesh recorded higher genetic variability for seed length, width and seed weight (Sindhu, 1995).

Kumar and Toky (1996) reported variation in seed germination and seedling growth of *Albizia lebbek* collected from 12 provenances.

Teak drupes collected from Topslip of Tamil Nadu registered increased size and weight compared to those of Karnataka, Andhra Pradesh and Maharashtra (Masilamani, 1996).

Toky *et al.* (1996) observed that in 3 year old *Albizia lebbek* trees from 12 provenances exhibited wide ranges and significant variations in their height (3.4 to 5.6 m), Diameter at Breast Height (DBH) (3.3 to 6.3 cm) and biomass (2.7 to 9.4 kg tree⁻¹).

According to Kandya (1997) teak seeds collected from 8 distant sources of Madhya Pradesh showed wide variations in seed filling, seed colour and seed germination potential.

Mani *et al.* (1997) concluded that garden land and tankbed sources were the best for collection of good quality seeds for elite seedling production in *Acacia nilotica*.

Manonmani (1997) reported that sandal seeds collected from coimbatore proved superior than other places.

Manonmani and Vanangamudi (1997) found that teak drupes collected from Topslip source outperformed others. This source contained more big size class and one seeded drupes indicating their close relationship which resulted in more weight and higher germination and seedling vigour.

According to Mishra *et al.* (1997b) neem seed collected from five different states exhibited wide variations for the germination and seed morphological parameters. Seeds from Kanpur (UP) recorded maximum seed breadth. While seeds from Karnataka state excelled for other parameters.

Sivagnanam *et al.* (1997) noticed a significant variation in all seed attributes except seed germination among seed sources maximum in western zone while, seed breadth and weight of seed and kernel were more in high rainfall zone.

Srimathi (1997) observed physical and physiological variations in the seeds of Amla, Jamun and Ber collected from different localities.

Seeds of *Acacia nilotica* collected from seven seed sources exhibited significant variations in their physical and physiological characters (Vanangamudi *et al.*, 1998c).

2.2. SEED TESTING PROCEDURES

2.2.1. Pre-treatments for breaking dormancy

Kumar and Purkayastha (1972) reported that sulphuric acid treatment gave good germination in *Acacia* and *Albizia* than soaking in cold water for 24 h.

Nagaveni and Srimathi (1980) have shown that sandal seed dormancy could be broken and germination hastened by soaking in 0.05% gibberellic acid for 12 to 16 h.

Sheikh (1980) reported that acid scarification of *Cassia fistula* seeds for 30 min gave higher germination of 68 per cent while it was only 24 per cent in control.

Nagaveni and Srimathi (1981) stated that sandal seeds scarified with acid for 50 and 60 min gave germination of 80 per cent in 70 days compared to 35 to 40 per cent in the control they also reported that the outer layer of endosperm becomes tough and forms a false seed coat and such seeds have a minimum dormancy period of two months.

Etejers *et al.* (1982) reported that dark brown seeds of *Parkia clanertoniana* gave better germination after acid treatment.

Pattanath (1982) found accelerated germination of *Acacia mearnsii*, *A. melanoxylon*, *A. nilotica*, *Albizia amara*, *A. procera* and *Grevillia robusta* seeds pre soaked in water for a period varying from 2 to 48 h.

Seed of *Leucaena leucocephala* were scarified with H_2SO_4 for 3, 5 and 7 min. than washed and soaked in water over night. The germination was in a faster rate in scarified seeds over control (Gupta *et al.*, 1983).

Roy and Pathak (1983) reported that best treatment for *Albizia richardiana* was soaking in sulphuric acid for 10 min which gave 81 per cent germination.

Komboo and Hellum (1984) reported that seeds of *Cassia siamea* scarified with concentrated sulphuric acid for 15 min. recorded higher germination than those subjected to mechanical scarification or water soaking.

Nagaveni and Srimathi (1985) suggested that soaking for longer durations made the sandal seeds non-viable.

Singh *et al.* (1985) reported that seeds of *Acacia catechu* soaked in GA_3 500 ppm recorded increased fresh and dry weight of the cotyledons.

Ananthapadmanabha *et al.* (1986) reported that Gibberellic acid treatment to intact seed coat of sandal seeds gave a decrease in \hat{A} -amylase activity and an increase in β -amylase activity.

Babeley *et al.* (1986) pre-treated seeds of *Albizia lebbek* with 98 per cent H₂SO₄ for 5-45 min and different concentrations of IAA. Results recorded better germination in 98 per cent H₂SO₄ for 45 min compared to rest of the treatments.

Rai *et al.* (1986) reported that in case of hard coated seeds like *Albizia lebbek*, *Cassia fistula* and *Cassia siamea*, repeated scarification with concentrated sulphuric acid gave upto 95 per cent germination.

According to Chhavi and Murthy (1987), application of GA₃ at higher concentrations had increased the germination and growth of *Cassia fistula*.

Maximum germination of 96-97.3 per cent was obtained in *Albizia lebbek* seeds by scarification and kept at alternating temperature (Khan and Tripathi, 1987).

Sur *et al.* (1987) reported that acid scarification treatment for 30 min was the best for *Acacia nilotica*, *A. auriculiformis* and *Leucaena leucocephala*

Lopez, and Aviles (1988) tried pre-sowing treatment with four different species of *Chilean prosopis* and best response was observed in the seeds scarified with concentrated H₂SO₄ for 24 min and soaked for 24 h in boiling water.

Natarajan and Vinaya Rai (1988) scarified the seeds of *Acacia auriculiformis* with concentrated H₂SO₄ @ 50 ml 100 g⁻¹ seeds and recorded higher germination over hot water soaking.

Millat-E-Mustafa (1989) reported that seeds of *A. lebbek* immersed in hot water followed by maintaining the seeds under controlled conditions of 28°C and 83% RH for 24 h gave 100 per cent germination.

Nagaveni *et al.* (1989) reported that soaking sandal seeds in IAA 100 ppm for 2-4 h was effective in obtaining quick and uniform germination.

Studies conducted by Ramamoorthy *et al.* (1989) in Pungam (*Derris indica* Lan) revealed that 15 min hot water soaking recorded higher speed of germination (1.8) and higher germination of 98 per cent. GA₃ treatment showed a marginal increase over control in root length, shoot length, vigour index and dry matter production.

According to Singh (1989), *Cassia glauca* seeds treated with IAA 50 ppm recorded 100 per cent germination with maximum seedling growth.

According to Mukhopadhyay *et al.* (1990), a significant increase in germination per cent of *Peltophorum ferrugenum* seeds was noticed when soaked in GA₃ solution for 12 to 24 h.

Sehgal and Batlej Singh (1990) stated that soaking the seeds of *Pistacia integerrima* in concentrated sulphuric acid for 20 min stimulated germination compared to control.

Unnikrishnan and Rajeeve (1990) reported a significant increase in germination percentage of teak seeds treated with 300 ppm IAA compared to control and GA₃.

Bhattacharya *et al.* (1991) reported that *Eucalyptus* hybrid seeds gave better germination and vigour index when treated with GA₃ @ 100 ppm followed by KNO₃ @ 500 ppm than the control.

Catalou *et al.* (1991) found the germination improvement in *Prosopis flexuosa* and *Prosopis alba* seeds with hot water treatment and scarification.

Cassia fistula and *Bauhinia purpurea* seeds when treated with IBA @ 300 ppm recorded higher germination of 69.5 and 97.5 per cent, respectively against other treatments such as IAA and NAA (Gopikumar *et al.*, 1991).

Scarification of *Tamarindus indica* seeds with concentrated sulphuric acid for 10 min gave 96 per cent germination compared to control (39 per cent) (Srimathi *et al.*, 1991).

Sudhakar (1991) recorded higher germination with seeds of *Acacia nilotica*, *Albizia lebbek* and *Acacia leucophloea* when subjected to acid treatment compared to untreated control.

According to Danthu *et al.* (1992) 95 per cent sulphuric acid scarification for 14 min or 24 h pregermination in water accelerated the germination in *Acacia senegal*.

According to Tewari (1992), soaking teak seeds in concentrated sulphuric acid for about 20 min and thorough washing in running water before sowing improved the germination.

Virendra Singh (1992) observed that higher germination percentage was obtained by treating the spruce seed with 1.5×10^{-5} m concentration of kinetin after 72 h of soaking.

Ahmed *et al.* (1993) found that sulphuric acid scarification increased the germination from 59.5% (control) to 80.2% in all the four tree species viz., *Albizia odoratissima*, *A. chinensis*, *Indigofera teysmannii* and *Tephrosia candida*.

Bimlendra and Toky (1993) stated that the germination of *Albizia* seeds was almost doubled when treated with H₂SO₄ for 30 min as compared to control.

Masana and Mawazin (1994) reported that slicing off the end of the tamarind seed gave better germination (92 per cent) compared to control (86.7 per cent) and other cold water treatments.

Padma *et al.* (1994) reported that sulphuric acid scarification of seeds of *Albizia lebbek* and *Leucaena leucocephala* for 30 min. and *Samanea saman* for 45 min improved germination with hot water soaking at 80°C for 5 min, *Leucaena leucocephala* gave maximum of 88 per cent germination while it was minimum of 14 per cent in *Albizia lebbek*.

Pistacia lentiscus seeds scarified for 50 seconds was the simplest and quickest method of improving the speed of germination (Piotto, 1995).

Adansonia digitata seeds treated with concentrated sulphuric acid for six to twelve hours led to germination of more than 90 per cent of the seeds within twenty days of sowing (Danthu *et al.*, 1995).

Palani *et al.* (1996) stated that *Albizia lebbek* seeds treated with IAA 100 ppm recorded higher germination per cent, root length, shoot length when compared to water soaking and other treatments.

Vijaya *et al.* (1996) observed a germination of 92 per cent in teak seeds treated with GA₃ (0.3%) while untreated seeds recorded only 52 per cent germination.

Manonmani (1997) stated that acid scarification using sulphuric acid at 50 ml 100 g⁻¹ of drupe for one hour followed by water soaking for 24 h improved the germination and seedling vigour of teak drupes collected from Kallar which were characterized by poor germination and also stated that the exogenous application of 0.05% GA₃ enhanced the germination and seedling vigour in sandal seeds.

According to Ali *et al.* (1997), in *Albizia procera* cold water soaking gave better results than hot water treatment (50°C & 100°C) for 3 min.

Venkatesh *et al.* (1997b) reported that soaking of Pungam seeds in 100 ppm IBA for 12 h gave higher germination, while GA₃ 100 ppm soaked seeds enhanced shoot length, total leaf area than other treatments.

Teak fruits collected from moist localities when subjected to wetting and drying for 7 days and soaking in cowdung solution for 24 h had enhanced germination (Chacko *et al.*, 1997).

According to Dhanda and Sunil Buri (1997), *Albizia lebbek* seeds after hot water treatment gave high germination within 21 days when compared to cold treatments.

According to Dod *et al.* (1997) seeds of Rayan (*Manilkara hexandra*) were subjected to ten different treatments including acid scarification, GA₃ 100 ppm and cowdung slurry treatment. Among various treatments, water soaking for 16 h and GA₃ 100 ppm soaking for 16 h recorded highest germination and seedling growth parameters.

Maitreyee Kundu *et al.* (1997) reported that the seeds of *Alstonia scholaris* pre treated with IAA 200 ppm outperformed than others recording three and five fold increase in germination and vigour respectively over dry seed control. Among wet treatments, water soaking for 24 h performed better.

Murugesh *et al.* (1997) reported that seeds of Amla (*Embllica officinalis*) soaked in Kinetin 100 ppm for 12 h proved effective for increasing the seed germination and seedling growth compared to the rest of the treatments.

Rajasekar *et al.* (1997) stated that sandal seeds treated with concentrated sulphuric acid for 15 to 20 min followed by soaking in GA₃ 0.05% for 12 h improved the germination upto 80 per cent.

Sudarsana Rao *et al.* (1997) treated the seeds of *Delonix regia*, *Tamarindus indica*, *Peltophorum ferruginum* and *Leucaena leucocephala* with prechilling, hot water treatment, acid scarification and soaking with 200 ppm GA₃. Results revealed that 60 min acid scarification for gulmohar and 20 min acid scarification for subabul and tamarind gave significant increase in germination.

The germination of *Syzygium cuminii* seeds reached maximum when soaked in 100 ppm IBA (12 h) followed by 1% NaH₂PO₄ (24 h) (Vanangamudi *et al.*, 1998a).

2.2.2. Germination medium

Magini (1962) suggested sand as germination substratum for the species that have higher germinative period, for increase *Rosa* spp., *Pinus caribaea*, *P. elliottii* and *P. palustris* or with larger seeds, for examples *P. pinca* and *Quercus* spp.

Seedling height and vigour index was maximum in sand medium for *A. auriculiformis*, *A. holosericea* and *Prosopis juliflora* (Rajasingh, 1987).

Anoliefo and Gill (1992) suggested sowing of *Bauhinia monandra* seeds in sandy soil for higher germination and biomass production than garden, clay and loamy soils

Seeds of *Ephedra gerardiana* sown in sand medium gave maximum germination, and more number of seeds germinated with emerging period of day when compared to soil and filter paper (Bhagat *et al.*, 1992 a).

Bhagat *et al.* (1992 b) reported maximum germination of 97 per cent in *Woodfordia fruticosa* seeds sown in sand medium compared to brick powder and soil which registered 58 and 43 per cent, respectively.

Deo *et al.* (1994) observed that soil, compost and sand in proportion of 1:2:1 and 1:2:2 gave excellent results in root trainers.

Negi and Singh (1995) reported that the seeds of *Pinus elliottii*, *P. greggii* and *P. patula* germinated in sand gave better results than those under nursery medium.

According to Mamta Purohit *et al.* (1998) seed germination of *Butea monosperma*, *Dendrocalamus strictus* and *Pongamia pinnata* showed better germination in sand medium.

Vanangamudi *et al.* (1998) concluded that sand medium followed by rolled towel were the best medium for conducting germination test for *Albizia procera* seeds. Germination per cent and vigour index of *A. procera* recorded higher in sand medium followed by rolled towel.

2.2.3. Tetrazolium test

Kumar and Sharma (1981) conducted tetrazolium test for five seed lots of *Leucaena leucocephala* to determine the viability of seeds rapidly. They grouped the staining patterns into eight different categories of viable and non-viable seeds.

Results of the 3 seed lots of *Lagerstroemia parviflora* bisected longitudinally and stained with 0.1% triphenyl tetrazolium chloride for 5 h, were in agreement with germination tests (Babeley and Kandya, 1986).

Chloroxylon sweetinia seeds cut and soaked in 0.1% tetrazolium solution were used to differentiate the viable and non viable seeds (Yadav *et al.*, 1986).

In *Dendrocalamus strictus* examination of longitudinal section stained seeds with 0.1 per cent tetrazolium chloride for 6 h showed several abnormalities of the embryo (Karivaratharaju *et al.*, 1987).

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Bangarwa *et al.* (1995) reported that nursery germination and establishment can be predicted on the basis of laboratory germination and the tetrazolium test in *Dalbergia sissoo*.

2.2.4. VIGOUR TESTS

2.2.4.1. NaCl salt stress test

Bangash (1977) reported that germination decreased with increasing salinity when tested in six tree species including *Albizia lebbek*. Seedling survival under field conditions was also affected by salinity. *Acacia arabica*, *Albizia lebbek* and *Zizyphus jujubha* were tolerant to saline conditions.

Tomer and Yadav (1980) reported that the germination, shoot and root length of *Acacia nilotica*, *Pongamia pinnata* and *Prosopis juliflora* were reduced and mortality increased with increase in the electrical conductivity (EC), Sodium Absorption Ratios (SAR) and Residual Sodium Carbonate (RSC) when compared with control.

According to Misra and Singh (1981), germination of *Acacia arabica*, *Acacia catechu* and *Albizia lebbek* in solutions of NaCl + Na₂SO₄ + CaCl₂ was little affected at electrical conductivities upto 12, 8 and 12 m.mhos, respectively.

Tomer and Yadav (1982) observed that height increment of 4 months old *Albizia lebbek* seedlings was reduced by irrigation with saline water of EC 5 and 10 m.mhos cm⁻¹. With sodic waters, no adverse effect on growth was observed until 240 days after transplanting.

Gupta *et al.* (1987) reported that under sandy soils safe and toxic limit of salinity of *Albizia lebbek* was 2.5-11.0 dSm⁻¹.

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2.2.4.2. pH test

Albizia lebbek seeds recorded 40-60 per cent germination under high pH range of 9-11 and some fodder *Albizia* sp. recorded maximum germination of 78.6 per cent under pH 8 (Roy, 1990).

The rooting potential was the highest in acidic pH of 6 and low in 3 and 4 and death of the seedling was noted at pH2 in *Rhizophora mucronata* (Kathiresan *et al.*, 1996) and in *R. apiculata* (Kathiresan and Thangam, 1990).

2.2.4.3. Poly Ethylene Glycol (PEG) test

Osmotic priming with PEG is known to reduce germination time, synchronize germination, improve the percentage germination and seedling stand (Guedes *et al.*, 1981).

Inorganic salts such as KNO_3 (Ells, 1963), K_3PO_4 (Cantliffe, 1981) and a chemically inert compounds, Poly Ethylene Glycol 6000 (PEG 6000) (Bodsworth and Bewley, 1981) or Poly Ethylene Glycol 8000 (PEG 8000) (Ali *et al.*, 1990) are materials most commonly used to adjust osmotic potential.

Umarani *et al.* (1997) reported that soaking in 0.25 per cent PEG for one day was advocated to maximise viability and vigour in neem.

Edgar Piedrahita (1997) reported that osmoconditioning of *Pinus patula* seeds with PEG 6000 at -0.6, -1.0 and 1.6 MPa resulted in reducing the time of initial germination, increasing the vigour of the seeds and synchronizing germination time.

Vanangamudi *et al.* (1998b) advocated that soaking of neem seeds in 2.5 per cent PEG for a duration of one day for maximising germination and vigour.

2.2.4.4. Accelerated aging test

Sur *et al.* (1987) reported scarified seeds of *Acacia auriculiformis*, *Acacia nilotica* and *Leucaena leucocephala* subjected to short term accelerated aging at 100% RH and 40°C temperature showed loss of vigour and viability, compared to untreated control.

Vanangamudi *et al.* (1993) subjected the seeds of *Pinus roxburghii* to different artificial ageing at 41°C and 100% RH for different periods. The germination of the seeds after aging varied from 15 to 69 per cent.

Significant differences between progenies were observed for germination after accelerated aging. Vigour index and germination after accelerated aging were positively associated (Bangarwa *et al.*, 1995).

The teak drupes aged for 15 days registered higher germination (53.2%) than non aged seeds (21.4 per cent) and it recorded more seedling vigour (Manonmani and Vanangamudi, 1997a).

Neem and Jamun seeds collected from Coimbatore and Mettupalayam when subjected to accelerated aging test behaved differently for viability and seedling vigour. Germination of jamun dropped to less than 50 per cent on 4th day after aging whereas it took 6 days for neem (Vanangamudi *et al.*, 1997).

2.2.5. Seed health testing

Singh *et al.* (1978) reported that *Colletotrichum dematium* f.sp. *truncata* found to be living in the pods of *Albizia lebbek* at Varnasi.

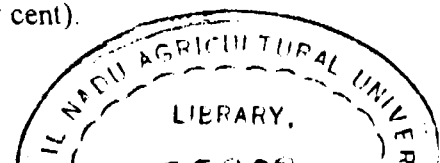
Davan (1986) identified 15 fungal genera and 10 species with *Aspergillus* and *Penicillium* spp. being predominantly found. Occurrence of fungi were much higher in blotter medium than on the Agar plate tests. The germination of seeds was adversely affected by storage fungi.

Twentyone fungal species belonging to 12 genera, mostly developed only on seed surfaces were isolated from seeds of *Acacia catechu*. Fungi causing internal infections were identified as *Aspergillus niger*, *A. flavus*, *A. tamarii*, *Curvularia lunata*, *Fusarium oxysporum*, *F. moniliforme*, *F. equiseti* and *Mycelia sterilia* (Vijayan and Rehill, 1989).

Masilamani (1992) reported that in *Prosopis juliflora* pods collected from natural forest, showed heavy microbial populations (fungi, bacteria and actinomycetes). The seeds extracted from infected pods were lesser in germination (21 per cent).

According to Mamta Purohit *et al.* (1996) the seeds of *Pithecellobium dulce*, *Tamarindus indica* and *Terminalia bellerica* from different locations gave more than 70 per cent germination and eight fungal species. *Aspergillus*, *Chetomium* spp. and *Rhizopus stolonifer* were isolated from the seeds of all three species.

Manonmani (1997) observed variations due to seed sources and months of storage for fungal infection in teak. She stated that the fungal infection was highest (13.58 per cent) in Mettupalayam than Coimbatore (10.73 per cent).



Mohanani (1997) assessed the seed health of 4 selected tropical tree seeds. Occurrence of *Alternaria*, *Sclerotium* spp, *Rhizoctonia* spp, *Fusarium* spp, and *Bipolaris* spp were observed in the tree seeds which causes seed borne diseases to seedlings.

2.3. NURSERY TECHNOLOGIES

2.3.1. Container size

Containers have passed through a number of evolutionary shapes and designs with the advancement of forestry. Different kinds of containers, i.e., earthen pots and tubes, palmyrah and bamboo baskets, seed boxes, leaf cups or donas, tin trays, manure bricks and even the seedlings mossed by cylindrical roll of moss were used in the past (Dhiman and Sood, 1994).

Most of these containers, however, do not possess the chief requirements of lightness and cheapness. They were, therefore, gradually replaced by light weight, durable, easy to transport, cheap and resistant "Polythene" bags (Nagarathnam, 1959 and Nagarathnam, 1972).

Banerjee (1973) reported that seeds of *Acacia auriculiformis* sown in 20x15 cm polypots having opening at both ends gave better results.

Davidson and Sowa (1974) demonstrated that containerised seedlings perform well in mined areas and on severely eroded forest soils (Dickerson, 1973).

Amidon *et al.* (1982) have reported that containerized long leaf pine (*Pinus paulistris* Mill) seedlings with intact root systems had better survival and began to

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grow early than bare root stock. Container grown seedlings tended to perform better on adverse sites than bare root seedlings.

Winter (1983) observed that the best seedlings of *Prosopis* were obtained from 6x20 cm polyethylene pots.

Keshavachandran and Nair (1985) reported that the sowing of cocoa seeds in larger size bag (30x20 cm) was the most suitable to raise seedlings which did not affect germination.

Natarajan and Jayaraj (1986) reported that *Acacia* seedlings grown in 25x13 cm gave better results than in 20x10 cm, 20x15 cm and 25x10 cm bags.

Vinaya Rai and Natarajan (1988) reported that optimal polypot size for raising *Casuarina equisetifolia* was 15x20 cm.

According to Mishra and Bhatnagar (1989) one year old *A. lebbek* seedlings raised in 30x70 cm polybags filled with garden soil registered maximum biomass of 801.4 g seedling⁻¹ upto 5 months.

Venkateswarlu *et al.* (1990) reported that increasing container size leads to increased growth, nodulation and nodule dry weight at 30 and 60 days after sowing.

Kannan and Paliwal (1992) reported that *Albizia lebbek* seedlings exhibited more drymatter production when raised under nursery conditions.

Mohit Gera (1997) conducted a study on polybag size in *Albizia procera* and found that polybag with 23x11 cm size gave best performance for almost all the seedling parameters.

2.3.2. Root trainer

Root trainer is a container, made up of plastic material which promote growth rate and increase quality seedlings by removing the elements obstructing root growth (Mohan, 1994a).

Polybag raised seedlings have many disadvantages viz., scanty lateral root development, frequent shifting and low establishment in the field. But root trainer raised plants have straight and profuse lateral roots and in out field trials it began growing soon after planting and nearly four times faster than polybag seedlings (Deo *et al.*, 1994).

Rips of about 2 mm on the inner cavity which intercept spiralling roots and force the developing roots to grow downward have been recommended by Kinghora (1974).

The volume of the cavity has a significant effect on size and growth rate of seedlings (Endean and Carlson, 1975) and it increased with increasing container volume of the root trainer (Carlson and Endean, 1976).

Alm *et al.* (1982) after growing seedlings in series of different container concluded that seedling size generally increased with rooting volume of the root trainer.

Barnett and Brissette (1986) found that species intolerant to crowding (long leaf pine) grew bigger in large volume containers with a long growing density, other pine

species (loblolly pine) could be produced in small volume containers with a high growing density.

Dakshindas (1994) raised eight different species in five types of root trainers and polythene bags filled with different media. He revealed that the root development varied from species to species and aerial root pruning was evident but in a few cases root was found elongated beyond the bottom. And the seedlings raised in polythene bags were healthy but their roots either penetrated the ground or were coiling.

Bahadur (1994) grown 16 species in root trainers having top diameter 4.8 cm, bottom diameter 1.5 cm and length 11.8 cm and concluded that except for *Soymida febrifuga* the root length in almost all species was more than in the free conditions. And the appreciable difference in the root length makes a seedling in the root trainer more versatile than other seedling.

Mohan (1994b) inferred that the growth of *Gmelina arborea* seedlings in root trainers (3000 book type) was much better than in the polythene bags.

The seedlings of semal and sissou raised in Hiko type root trainer (length 12 cm, top diameter 5 cm and bottom diameter 2 cm) shown better root development without root coiling than the single cell root trainers (10 cm x 5 cm x 2 cm) (Deshmukh, 1994).

Sixty days after sowing of *Eucalyptus* spp in root trainers, showed positive effect of container volume on height, Difference in collar diameter of 225 cc container grown plants and 150 cc container grown plants was not remarkable (Chaurasia and Yadava, 1994).

Khedkar and Subramanian (1996) stated that planting stock of *Bombax ceiba*, *Acacia catechu*, *Dedrocalamus strictus* and *Dalbergia sissoo* were raised in root trainers of 150 CC.

2.3.3. Potting mixture

Norberto (1939) developed methods to improve germination of teak seeds. Best results were obtained with mixtures of ash, clay loam in the ratio of 1:2 or 1:5.

Brown and Pokorny (1975) indicated that bark had physical properties, making it a possible alternative to peat moss.

The amount of organic material used in growing media varies considerably, generally ranging from 25-50 per cent (by volume), but sometimes upto 100 per cent (Mastalery, 1977).

The growing media is relatively inexpensive, readily available and encourages mycorrhizal development (Ruchle and Marx, 1977).

Bhoja Shetty (1977) suggested that red soils are suitable for *Eucalyptus* and some *Acacias*.

Pine bark had also been suggested as medium for growing plant (Scarborough, 1979).

Shafiq *et al.* (1978) concluded that different mixtures of alluvial sandy soil, heavy clay soil and farm yard manure in 2:1:1 proportion is best for *Eucalyptus*.

Beardsell *et al.* (1979) found that some of the physical properties of growing medium mixtures, such as water holding ability would be predicted from the characteristics of the individual components.

Vinaya Rai *et al.* (1980) reported that *Eucalyptus tereticornis* grown under shola soil (Forest soil) gave better results than soil, sand, soil + shola soil.

Keshavachandran and Nair (1985) stated that a potting mixture of soil, sand and FYM at 1:1:2 gave good germination and vegetative growth in cocoa.

Roy *et al.* (1985) studied the physiological characteristics of seedlings of *Acacias* under nursery conditions raised in polythene bags containing decomposed leaf compost and loamy soil in 1:4 proportion.

Singh *et al.* (1985b) obtained maximum germination of *Populus ciliata* when sown in sand medium at more than 4 cm depth.

According to Bahuguna *et al.* (1989) higher seed germination was recorded when seeds dibbled in nursery bed filled with FYM: sand in the ratio of 1:1.

Khan and Tripathi (1989) stated that higher seed germination of 80 per cent in *Alnus nepalensis* and 60 per cent in *Schima khasiana* were obtained when seeds sown in sandy loam soil.

Landis (1990) stated that rice husk had been tested as an organic component in USA and reported that this medium is cheap readily available, consistent in quality, resistance to decomposition and mixes well.

Humus and sand in the ratio of 2:1 has given good results in *Casuarina equisetifolia* (Rimando, 1981).

Triwahyono and Mimbar (1991) showed that soaking (36 h) of *Calliandra calothyrsus* seeds and soil planting media gave a good germination and produced vigorous seedlings.

According to Dolly Wattal Dhar *et al.* (1992) farm yard manure was found to be the best medium for raising healthy and vigorous seedling of *Leucaena leucocephala* in polythene bags.

According to Gupta (1992) the best suitable potting mixture for *Albizia lebbek* was 10% tank silt + 4% FYM + 40 ppm N, which recorded increased seedling height at 120 days after sowing.

Pyarelal and Karnataka (1993) reported that *Quercus leucotrichophra* seedlings could be raised by sowing the seeds in the soil mixture consisting soil, sand and farm yard manure in 2:1:1 ratio in nursery beds for better germination.

According to Shamet *et al.* (1994) potting mixture of soil, sand, moss and FYM at 1:1:1:1 ratio gave maximum height growth in *Pinus gerardiana* while soil, sand and moss in equal proportions gave larger caliper (diameter) growth. Maximum seedling survival (79 per cent) achieved at 1/2" layer saw dust mulch whereas height and caliper growth were best in a 1/2" layer needle mulch.

Chaurasia and Yadava (1994) were tried the ingredients viz., soil, compost, sand, gravel, rice husk, waste from mill, bagasses, groundnut shell, wood shavings and saw dust.

They found that one part of rice husk, 2 part of sand and 1 part of saw dust was good with 21.8 per cent air space. Ingredients were tested for toxicity and found suitable for use.

Deo *et al.* (1994) observed that soil, compost and sand @ 1:2:1 and 1:2:2 ratio gave excellent result and compost was better than farm yard manure to prepare soil mix for root trainers.

The coconut husk was superior to the conventional potting medium such as sand and soil in terms of nutritional status, organic content, electrical conductivity etc., and it promoted growth of tree seedlings (Subramanian, 1994).

The potting mixture containing soil : compost : sand at 1:1:1 ratio gave better results for *Gmelina arborea* (Mohan, 1994b).

The relative pore space of growing medium affected seedling growth and development in containers. A properly balanced pore space provided good gaseous exchange for the root system and directly affected water and mineral nutrients uptake (Dhiman and Sood, 1994).

Sudhakara *et al.* (1995) Stated rooting medium containing sand, soil and farm yard manure in the ratio of 1:1:1 was significantly better than the rooting medium with sand and soil in the ratio of 1:1.

The composition of media by 90 per cent portion of sugar cane bagas mixed 10 per cent portion of mixed additive (soil : green manure : manure in the proportion of 1:2:3) revealed better growth of *Acacia mangium* seedlings (Lempang, 1995).

Rajannan and Lakshman (1996) reported that Rayan (*Manilkara hexandra*) seeds sown in sand media gave 40 per cent germination against 25, 15 and 6 per cent in pot mixture, red earth and farm yard manure, respectively on the 26th day after sowing.

According to Biradar *et al.* (1998) sandal seeds sown in soil mixture of 1:2:1 of sand : soil : FYM recorded highest germination.

Casuarina equisetifolia grow well on 1:1:1 mixtures of alluvial sand soil, heavy clay and farm yard manure (Jayaraj, 1998).

Potting media containing sand and mushroom in the ratio of 2:1 produced significantly better total dry weight value than all the treatments including the control. Also this treatment gave the maximum value from nine out of the fifteen characters assessed (Maria Dominica Savio *et al.*, 1998).

2.3.4. Seedling grade study

Wakeley (1954) found that southern pine seedlings with initial top length between 10 and 17.5 cm survived better than those with longer or shorter tops.

Minko (1974) reported in *Pinus radiata* that mortality was least in the 25 to 37.5 cm seedlings and was the greatest with the smallest seedlings. The incidence of death of the terminal shoot was directly proportional to seedling height and was greater during the first year after planting.

Venator (1983) found that intermediate sized seedlings of loblolly pine (top length 10-17 cm; root collar diameter between 0.31 and 0.47 cm) survived better than small or large seedlings in drought years.

Tuttle and ETAL (1987) found that the survival of loblolly pine seedlings was negatively related to initial seedling height on adverse site and that survival had a slight positive relationship with initial seedling top height on non-adverse sites.

Lauer (1987) reported that the initial seedling size did not affect survival of long leaf pine (*Pinus palustris*), but seedlings with root collar diameter 1.09 cm had improved the height.

Singh *et al.* (1988) found that the growth and survival of source seedling increased with increase in initial seedlings height and were significantly lower in the first 2 height classes (<7.5-<12.5 cm) than in the others (12.5 - 22.5 cm). All the later classes produced seedlings of height >30 cm which is considered to be the best size for planting in the field. They concluded that spruce seedlings below 12.5 cm in height should be culled out at the time of transplanting.

Seedlings of loblolly pine (*Pinus taeda*) with top lengths less than 15 cm and with root collar diameter less than 2.5 mm survived significantly more than larger seedlings (Shiver *et al.*, 1990).

The performance of the silver fir seedlings below 5 cm in height in terms of survival, seedling growth and seedling dry weights was poorest compared to other seedling height classes. The result indicated that seedlings below 5 cm in height should be culled out at the time of transplanting (Bhagat *et al.*, 1990).

Venkatesh *et al.* (1997a) suggested in Pungam that tallest seedling class of 51-60 cm height recorded the highest (94.2 per cent) survival and better seedling morphometric attributes than the other height classes.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present study was carried out to elucidate the seed source variation and standardize the seed testing procedures for vagai (*Albizia lebbek*). Studies were also conducted to standardize a few nursery technologies for elite seedling production.

The experiments were conducted at Forest College and Research Institute, Mettupalayam - 641 301 and in the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore - 641 003 during 1996-1999.

3.1. MATERIALS

The seeds of vagai collected from the identified Candidate Plus Trees (CPTs) from different seed sources in five agroclimatic zones of Tamil Nadu formed the basic materials for the study.

3.2. METHODS

3.2.1. SELECTION OF CANDIDATE PLUS TREES (CPTs) AND COLLECTION OF SEEDS

A survey was undertaken in different agroclimatic zones of Tamil Nadu and CPTs were selected based on the superior morphometric traits such as tree height, Girth at Breast Height (GBH), Clean Bole Height (CBH), tree health and a good pod bearing capacity. Sufficient care was taken to see that about 100 m distance existed in between the two CPTs identified. The details of the number of identified CPTs (Plate 1 and 2) from each seed source along with their agroclimatic zones (Fig. 1) are given in the Table 1. The physiographic characteristics of the seed sources are also furnished in this Table.

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3.1. MATERIALS

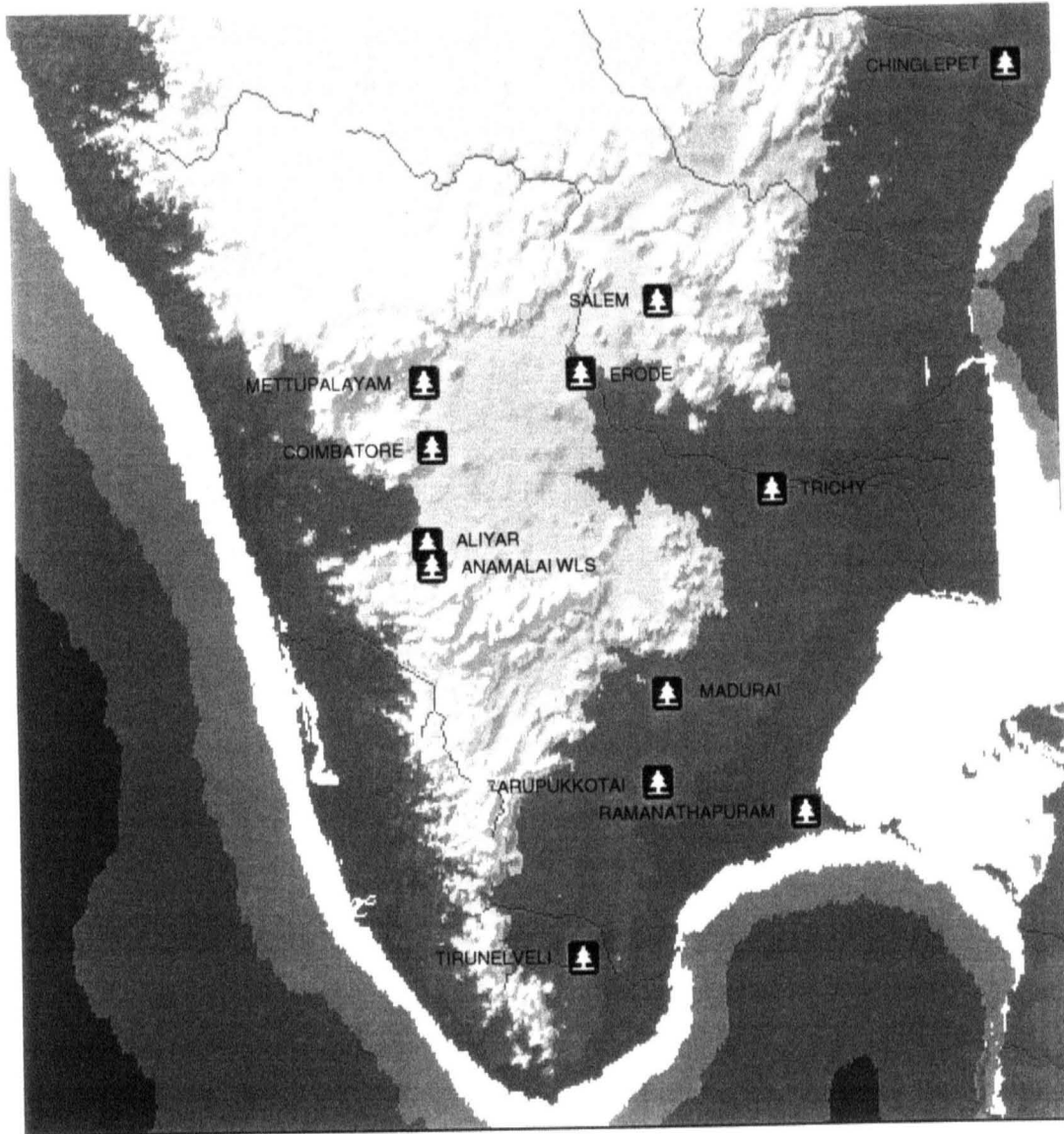
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Fig.1. Map showing the different sources of seed collection in *Albizia lebbek*



Southern zone

Tirunelveli
Ramanathapuram
Madurai
Arupukottai

Western zone

Anamalai WLS
Aliyar
Coimbatore
Mettupalayam
Erode

North Western zone - Salem
North Eastern zone - Chinglepet
Cauvery Delta zone - Trichy

Plate 1. Identified CPT's of *A. lebbek*

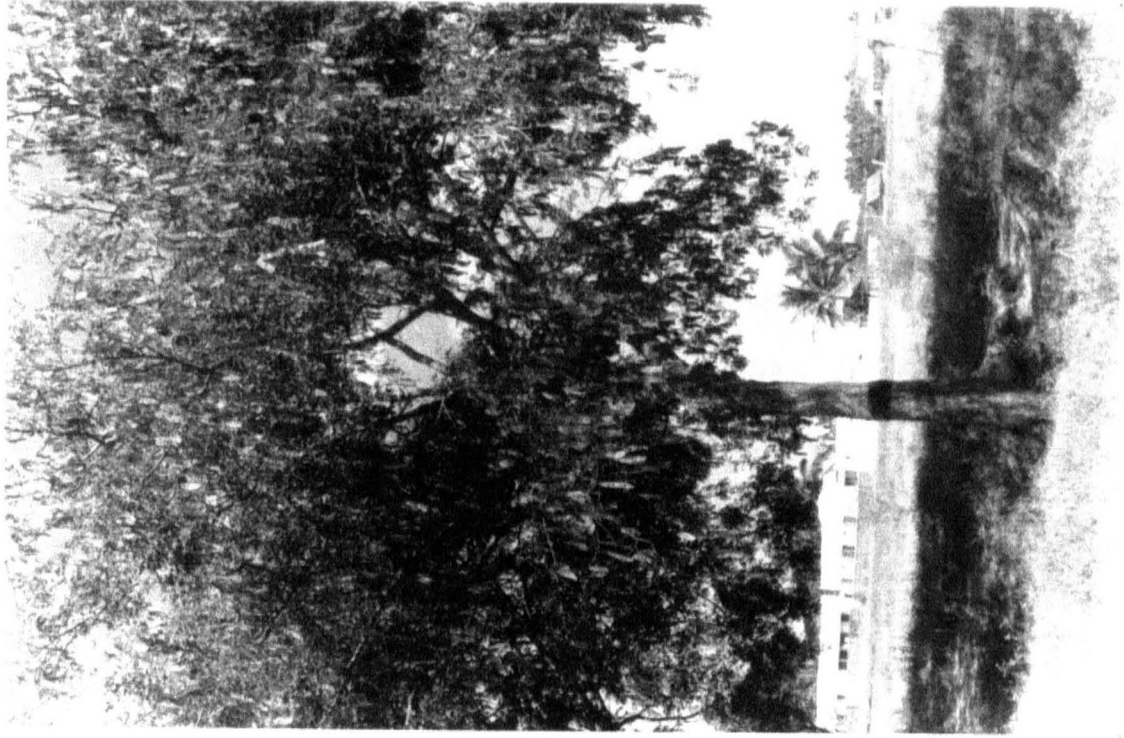




Table 1. Physiographic details of different seed sources of *A. lebbek*

Seed source	Latitude	Longitude	Altitude (m)	Rainfall (mm)	Rainfall time	Geology & Soil	pH	Agroclimatic zone
Tirunelveli	8°43'N	77°41'E	50	808	Oct-Dec	Red soil	7.0	Souther
Ramanathapuram	9°12'N	78°25'E	92	750	Oct-Dec	Red Soil	7.0	Souther
Madurai	9°55'N	78°7'E	70	856	Oct-Nov	Red Soil	7.5	Souther
Arupukottai	9°30'N	78°5'E	90	700	Oct-Dec	Red Soil	6.5-7.0	Souther
Anamalai WLS	70°35'N	76°56'E	160-2700	960	June-Dec	Laterite	6.5-8.4	Western
Aliyar	10°39'N	77°0'E	220-1500	800	June-Dec	Granite- Gnessic Sandy loam (Cambian)	6.0-7.0	Western
Coimbatore	11°1'N	76°58'E	427.6	1299	June-Dec	Clay & clayey loam	6.5-7.5	Western
Mettupalayam	11°18'N	76°56'E	300	800	Oct-Dec	Clayey loam	6.0-7.0	Western
Erode	11°27'N	77°41'E	110	685	Oct-Dec	Granite- Gnessic Clayey (pre-cambian)	6.0-7.0	Western
Salem	11°39'N	78°12'E	191-1.525	843	June-Dec	Red non- calcareous	6.7-8.5	N. West
Chinglepet	12°42'N	79°58'E	140	1152	Oct- Dec	Chanokites Fine Clay (cambian)	6.8	N. Easte
Trichy	10°48'N	78°42'E	150-180	858	June-Dec	Calcareous & clayey loam	7.0-8.5	Cauvery Delta

The pods of *Albizia lebbek* were collected at optimum harvest stage from the identified CPTs of different seed sources. The pods gathered from different CPTs were dried and the seeds were extracted manually by beating with pliable bamboo sticks. The seeds extracted from different CPTs were pooled sourcewise and utilized for the study.

3.2.2. EFFECT OF SEED SOURCE ON SEED QUALITY

The physical and physiological variations of seeds of different seed sources were studied here. The experiment was set up in Completely Randomized Design (CRD) with eight replications.

3.2.2.1. Measurement of physical characteristics of seeds

Ten seeds from each source were selected at random for measuring the following physical characteristics.

i) Seed length

The length of seed from the base to the tip was measured using vernier caliper and the mean expressed in millimetre.

ii) Seed breadth

The breadth at the middle of the seed was measured using vernier caliper and the mean expressed in millimetre.

iii) Seed thickness

The thickness at the middle of the seed was measured using vernier caliper and the mean expressed in millimetre.

iv) Individual seed weight

The seeds were weighed individually in an electronic top pan balance and the mean weight expressed in mg seed⁻¹.

v) Insect damaged seed

100 seeds in four replications were taken from each seed source and the number of insect damaged seeds was counted. The percentage was worked out as follows.

$$\text{Insect damaged seed (\%)} = \frac{\text{Number of insect damaged seeds}}{\text{Total number of seeds}} \times 100$$

3.2.2.2. Assessment of germination, seedling growth and biomass under nursery conditions at two, four and six months after sowing

The seeds from twelve different seed sources were scarified using commercial grade H₂SO₄ @ 600 ml Kg⁻¹ for 25 min. and washed thoroughly with running tap water to get acid free seed. Then, the seeds were soaked in cold water for 24 h. The pretreated and presoaked seeds were sown in polybags (15x25 cm size) filled with a potting mixture containing red soil, sand and farm yard manure in the proportion of 2:1:1 ratio. The experiment was set up in CRD with four replications of one hundred seeds each. The seedlings were raised as per standard nursery practices.

i) Germination

Twenty eight days after sowing, the number of germinated seedlings were counted and germination was expressed in percentage. On the ten randomly selected seedlings, the following growth measurements were recorded at two, four and six months after sowing.

ii) Root length

The seedlings were removed from the containers without damaging the root and washed thoroughly to remove the adhering soil particles. The root length was measured

from the collar region to the tip of the primary root using metre scale and the mean was expressed in centimetre.

iii) Shoot length

The shoot length was measured from the collar region to the growing tip of the seedling using metre scale and the mean was expressed in centimetre.

iv) Shoot collar diameter

The diameter of the shoot at the collar region was measured using a vernier caliper and the mean was expressed in centimetre.

v) Number of leaves

The number of leaves in each of the seedling was counted and the mean value was expressed in numericals.

vi) Number of nodules

The number of nodules present in the root system was counted in each seedling and the mean value was expressed in numericals.

vii) Root and shoot fresh weights

The root and shoot portion of the ten selected seedlings were cut and weighed in an electronic top pan balance. The mean values were expressed in g.

viii) Root and shoot dry weights

The root and shoot were separately, dried under shade for few hours and then dried in a hot air oven maintained at $85 \pm 1^\circ\text{C}$ for 24 h. After drying, they were cooled in a desiccator for 30 min. weighed and was expressed in g.

ix) Total dry weight

The total dry weight of the seedling was arrived at by adding root and shoot dry weights and was expressed in g.

3.2.2.3. Effect of seed source on survival and establishment of seedlings in the field

The three months old seedlings grown from twelve seed sources were planted using a spacing of 3x3 m in the field adopting RBD replicated three times. The observations viz., survival percentage, plant height, shoot collar diameter and number of leaves in five randomly seedlings were recorded in each replication.

3.2.3. STANDARDIZATION OF SEED TESTING PROCEDURES

3.2.3.1. Standardization of sample weight for submitted and working sample

The seed collected from twelve seed sources were treated as twelve seed lots for standardization of seed testing procedures. The seed lots were mixed thoroughly and divided using the mechanical dividers. It was ensured that the submitted sample reflected the composition of the whole seed lot and homogeneous in composition, without inflicting any bias during dividing. The working sample was determined by taking the weight of 2500 seeds. As per ISTA (1993) rules, ten times the working sample was the submitted sample. The sample sizes were expressed in g.

3.2.3.2. Standardization of purity analysis

The purity analysis was also carried out for the seed lots collected from twelve seed sources with the working sample as per ISTA (1993) rules.

The different components such as pure seed and inert matter were determined as follows and expressed in percentage.

$$\text{Purity (\%)} = \frac{\text{Weight of pure seed}}{\text{Total weight of working sample}} \times 100$$

$$\text{Inert matter (\%)} = \frac{\text{Weight of inert matter}}{\text{Total weight of working sample}} \times 100$$

3.2.3.3. Standardization of hundred seed weight

Measurement of seed weight was made on the pure seed component of the purity test and weight was normally expressed as the weight of 100 pure seeds. As per ISTA (1993), eight replications of 100 seeds each were counted from twelve seed lots. The standard deviation and co-efficient of variation were calculated. If the standard deviation calculated was below 4, then it confirms to ISTA (1993) standards.

3.2.3.4. Standardization of germination test requirements

3.2.3.4.1. Standardization of pre-treatments to break seed dormancy

1. Acid scarification

The seed samples taken from twelve seed lots were soaked in concentrated sulphuric acid for seven different time durations of 5, 10, 15, 20, 25, 30 and 35 min. The non-scarified seeds served as control. After scarification, seeds were thoroughly washed in running tap water to make the seeds acid free. The scarified seeds were evaluated for the following parameters.

i) Germination

Four replicates of 100 seeds each were germinated in germination trays filled with sand (ISTA, 1993) and kept in the germination room maintained at $25 \pm 2^\circ\text{C}$ temperature and $90 \pm 5\%$ RH. Count was made on the number of normal seedlings at 28 days after sowing and the germination was calculated and expressed in percentage.

ii) Root length

The root length of the ten normal seedlings was measured from the collar region to the tip of the primary root and the mean was expressed in centimetre.

iii) Shoot length

Ten normal seedlings were selected at random and length of the shoot measured from collar region to the growing tip. The mean shoot length was expressed in centimetre.

iv) Vigour index

The vigour index was calculated by using the formula suggested by Abdul-Baki and Anderson (1973) and expressed as whole number.

$$\text{Vigour index} = \text{Germination percentage} \times (\text{Root length} + \text{Shoot length}).$$

v) Drymatter production

The ten normal seedlings utilized for seedling measurements were first dried under shade and then dried in a hot air oven maintained at $85 \pm 1^\circ\text{C}$ for 24 h. After drying, they were cooled in a desiccator for 30 min. weighed and expressed in g.

2. Combination of acid scarification and GA₃

To break the hard seed coat dormancy in *Albizia lebbek*, the seeds were given with following treatments. The design used for this experiment was CRD.

Notation	Treatment
T ₀	Control (unsoaked seed)
T ₁	Commercial H ₂ SO ₄ 25 min. followed by water washings
T ₂	Commercial H ₂ SO ₄ 25 min. + 24 h water soaking
T ₃	Commercial H ₂ SO ₄ 25 min. + 48 h water soaking
T ₄	Commercial H ₂ SO ₄ 25 min. + GA ₃ 100 ppm soaking for 24 h
T ₅	Commercial H ₂ SO ₄ 25 min. + GA ₃ 100 ppm soaking for 48 h
T ₆	Commercial H ₂ SO ₄ 25 min. + GA ₃ 200 ppm soaking for 24 h
T ₇	Commercial H ₂ SO ₄ 25 min. + GA ₃ 200 ppm soaking for 48 h

The observations on germination was made with pre-treated seeds

3. Standardization of a suitable growth regulator

The seeds from twelve seed lots were given the following treatments.

Growth regulators	:	GA ₃ , IAA and IBA
Concentrations	:	100, 200, 300, 400 and 500 ppm each
Soaking duration	:	24 h

The design used for this study was CRD.

Before treating the seeds in growth regulators, they were acid scarified using the standard procedures. Treated seeds (4 x 100) were sown in sand medium and the following observations were made.

- i) Germination
- ii) Root length
- iii) Shoot length
- iv) Vigour index
- v) Drymatter production

4. Infusion of growth regulators

The seeds from twelve seed lots were scarified with commercial grade sulphuric acid for 25 min. and soaked in acetone based GA₃ 100 ppm and kinetin 100 ppm for 12 h. Scarified but unsoaked seeds served as control. After decanting the solution, the seeds were shade dried and tested for germination and seedling vigour. One hundred seeds were sown in sand medium for each treatment with four replications. The experiment was set up in CRD.

The following observations were recorded:

- i) Germination
- ii) Root length
- iii) Shoot length
- iv) Vigour index
- v) Drymatter production

3.2.3.4.2. Standardization of a suitable medium for germination

The seeds from twelve different seed lots were acid scarified and then sown in different media. The experiment was set up in CRD. The details of media are presented herein (ISTA, 1993).

1. Top of Paper

The seeds were laid on top of two layers of moistened germination paper placed in petriplates.

2. Between Paper

The seeds were placed between two layers of moistened germination paper and kept upright to facilitate germination.

3. Sand

Seeds were sown in germination trays filled with sterile sand having particle size between 0.8 mm and 0.05 mm diameter and pH range of 6.0-7.5.

The seeds sown in the above media were kept in a germination room maintained as per ISTA (1993) rules. The observations as hereunder were recorded.

- i) Germination
- ii) Root length
- iii) Shoot length

iv) Vigour index

v) Drymatter production

3.2.3.5. Standardization of quick viability (tetrazolium) test

Four replicates of 100 seeds each drawn at random from the pure seed fraction were used for this study. The design used for this study was CRD

1. Preconditioning method

The preconditioning methods include (i) acid scarification followed by 12 h water soaking and (ii) nipping off seed coat followed by 12 h water soaking.

2. Preparation method

- i) Complete removal of seed coat without injury to the embryo.
- ii) Removal of seed coat and splitting of the cotyledons with careful retention of the embryo in one of the cotyledons.
- iii) Removal of seed coat and cutting the cotyledons transversely.

3. Tetrazolium concentration

The seeds after preconditioning and preparation were soaked in 0.5 and 1.0% aqueous solution of 2, 3, 5-triphenyl tetrazolium chloride with pH range of 6.5-7.5 and kept in a hot air oven maintained at $40 \pm 2^\circ\text{C}$ for 2 h for staining.

The viable and non-viable seeds were grouped as per ISTA (1993) rules.

3.2.3.6. Standardization of vigour tests

3.2.3.6.1. NaCl salt stress test

The acid scarified seeds (4 x 100) were sown in sand medium and watered with different concentrations of NaCl viz., 0.25, 0.50, 0.75 and 1.00% to induce the salt stress. The irrigation with tap water served as control. The experiment was set up in CRD. The following observations were recorded.

- i) Germination
- ii) Root length
- iii) Shoot length
- iv) Vigour index
- v) Drymatter production

3.2.3.6.2. pH test

The acid scarified seeds from five seed lots each representing five agroclimatic zones were sown in sand medium with four replications of 100 seeds each. pH solutions ranging from 4 to 10 were prepared and used for watering the sand medium. The tap water served as the control. The experiment was set up in CRD. At final count day, the observations as mentioned below were recorded.

- i) Germination
- ii) Root length
- iii) Shoot length
- iv) Vigour index
- v) Drymatter production

3.2.3.6.3. Poly Ethylene Glycol (PEG) Test

The seeds of five seed sources after scarification with commercial grade sulphuric acid were soaked in solutions of Poly Ethylene Glycol (PEG) at different concentrations

viz., 0.25, 0.50, 0.75, 1.00 and 1.25% for 24 h. The water soaked seed formed the control. Then 4x100 seeds were sown in sand medium. The design followed was CRD with four replications. At final count day, the following observations were recorded.

- i) Germination
- ii) Root length
- iii) Shoot length
- iv) Vigour index
- v) Drymatter production

3.2.3.6.4. Accelerated aging test

Seeds of twelve seed lots were surface sterilized in 2% sodium hypochlorite (NaOHC1) followed by rinsing in sterile distilled water. The seeds were subjected to aging in an accelerated aging chamber maintained at $40 \pm 1^\circ\text{C}$ and $98 \pm 2\%$ relative humidity. For this, the acid scarified seeds were spread in a single layer on a bronze wire mesh seed holders kept in plastic boxes (12 x 12 x 5.5 cm size) containing water to a depth of 1 cm. The boxes were tightly covered with lids and then transferred to the aging chamber. Besides initial sampling (0 day aging), seed samples were drawn at 2, 4, 6, 8 and 10 days interval and tested for germination using 4 x 100 seeds sown in sand medium. The design used for this experiment was CRD. At final count day, the following observations were recorded.

- i) Germination
- ii) Root length
- iii) Shoot length
- iv) Vigour index
- v) Drymatter production



3.2.4.3.7. Standardization of seed health testing

1. Blotter medium

A sample of 4 x 100 seeds were drawn from the working sample of twelve seed lots. The experiment was set up in CRD. They were sown at equal distance in sterile petri plates containing three layer of moist filter papers (blotters). Then, they were incubated at $30 \pm 2^{\circ}\text{C}$ under 12 h of alternate cycles of light and darkness in a growth chamber fitted with two white fluorescence tube lights. As the blotter become dry by 4th and 5th day of incubation, a few drops of sterile distilled water were added. After 8-10 days of incubation, using stereoscopic binocular microscope the presence and frequency of seed borne fungi were identified to the generic level.

2. Agar medium

In this method instead of blotters the potato-dextrose agar was used as a medium to identify the presence of seed fungi. The procedure was the same as followed in blotter medium except the subsequent water addition after 4th and 5th day of incubation.

3.2.4. Standardization of nursery technologies for elite seedling production

3.2.4.1. Container size study

Seeds were sown in polybags of different sizes viz., 15x25 and 10x15 cm filled with standard potting mixture to study the effect of container size on seedling growth. The seedlings grown in raised bed formed the control. Completely randomised design with 3 replications was followed for experimentation. In each replication, 100 seeds were used. The following observations on seedling growth parameters were observed on one, three and five months after sowing in five randomly selected seedlings.

i) Root length

ii) Shoot length

iii) Shoot collar diameter

- iv) Number of leaves
- v) Number of nodules
- vi) Root and shoot fresh weights
- vii) Root and shoot dry weights
- viii) Total dry weight

3.2.4.2. Root trainer study

The seedlings were raised by sowing the seeds in different root trainer sizes viz., 150, 300 and 600 cc filled with standard potting mixture of red soil, sand and FYM in the proportion of 2:1:1 ratio. The seedlings grown in raised bed served as control. The design used for this study was CRD. There were four replications with 100 seed each. Observations on seedling growth parameters were measured with randomly selected five seedlings at one and three months after sowing.

- i) Root length
- ii) Shoot length
- iii) Shoot collar diameter
- iv) Number of leaves
- v) Number of nodules
- vi) Root and shoot fresh weights
- vii) Root and shoot dry weights
- viii) Total dry weight

3.2.4.3. Potting mixture study

To identify a suitable potting mixture for raising elite seedling, the following potting mixture combinations were attempted. The design followed for this study was CRD with three replications of 25 containers each.

T₁ - Red soil:sand:FYM (2:1:1)

T₂ - Red soil:sand:vermicompost (2:1:1)

T₃ - Red soil:sand:goat manure (2:1:1)

T₄ - Red soil:sand:poultry manure (2:1:1)

T₅ - Red soil:sand:sago waste (2:1:1)

T₆ - Red soil:sand:sand (2:1:1)

T₇ - Red soil:sand: vermiculite (2:1:1)

T₈ - Red soil:sand:leaf litter compost (2:1:1)

T₉ - Red soil:sand:raw coir pith (2:1:1)

The following observations were recorded on 28 days after sowing with five randomly selected seedlings.

- i) Germination
- ii) Root length
- iii) Shoot length
- iv) Vigour index
- v) Drymatter production

3.2.4.4. Seedling grade study

The six month old seedlings were graded in sufficient numbers according to height and diameter and planted in 30x45 cm size polybags filled with standard potting mixture. The seedling grade classes are as follows.

Seedling grade classes	Measurements
I. Height classes	
SH 1	15-25 cm
SH 2	26-45 cm
SH 3	46-60 cm
SH 4	61-75 cm
II Diameter classes	
SD 1	2.1-3.5 mm
SD 2	3.6-5.0 mm
SD 3	5.1-6.5 mm

The experiment was set up in CRD with seven replications with 25 seedlings each. The following observations on seedling growth parameters were taken initially and on one and three months after transplanting in five randomly selected seedling.

- i) Root length
- ii) Shoot length
- iii) Shoot collar diameter
- iv) Number of leaves
- v) Number of nodes

Individual nodes were counted and expressed in numbers.

- vi) Number of nodules
- vii) Root and shoot fresh weights
- viii) Root and shoot dry weights
- ix) Total dry weight

3.3. Statistical interpolation

The data collected from various experiments were analysed statistically adopting the methods described by Panse and Sukhatme (1978). The percentage values were transformed into angular (Arc sine percentage) values before carrying out statistical analysis.

RESULTS

CHAPTER IV

RESULTS

4.1. SELECTION OF CPTs

The average Girth at Breast Height (GBH), plant height and Clean Bole Height (CBH) for the CPTs of *Albizia lebbek* selected from twelve different seed sources were 180.1 cm, 17.8 m and 2.9 m, respectively (Table 2). The highest GBH, plant height and CBH were 288.6 cm, 23.7 cm (Anamalai WLS) and 3.7 m (Ramanathapuram) respectively. The lowest GBH, plant height and CBH were 128.3 cm, (Aliyar), 12.6 m and 1.9 m (Chinglepet), respectively.

4.2. EFFECT OF SEED SOURCE ON SEED QUALITY

4.2.1. Measurement of physical characteristics of seeds

i. Seed length

Variation among seed sources found to be non-significant. The average length of the seed measured for different seed sources was 9.76 mm (Table 3).

ii. Seed breadth

The breadth of individual seed had shown significant variation among seed sources (Table 3). The seed breadth was higher in the seeds collected from Coimbatore (7.9 mm) which was followed by seeds collected from Erode (7.10 mm) and Trichy (7.0 mm). The seeds collected Mettupalayam recorded minimum seed breadth (6.60 mm).

iii. Seed thickness

The difference among the seed sources found to be significant (Table 3). The average seed thickness was 2.30 mm.

Table 2 Mean morphometric traits for Candidate Plus Trees (CPTs) of *A. lebbek* in different seed sources

Seed source	No. of CPTs selected	Girth at Breast Height (cm)	Tree height (m)	Clean Bole Height (m)
Tirunelveli	5	165.2	21.2	3.6
Ramanathapuram	4	168.5	20.3	3.7
Madurai	5	185.5	18.3	2.8
Arupukottai	6	198.0	21.6	2.8
Anamalai WLS	8	288.6	23.7	3.5
Aliyar	6	128.3	16.6	2.5
Coimbatore	5	198.2	18.2	3.2
Mettupalayam	6	144.0	14.8	3.0
Erode	7	181.9	14.9	3.2
Salem	4	167.5	13.6	2.3
Chinglepet	5	165.8	12.6	1.9
Trichy	5	170.0	17.4	2.4
Mean	6	180.1	17.8	2.9

Table 3. Evaluation of physical characteristics and insect attack of seeds of *A. lebbek* in different seed sources

Seed source	Seed length (mm)	Seed breadth (mm)	Seed thickness (mm)	Weight of individual seed (mg)	Insect attack (%)
Tirunelveli	8.3	6.80	2.3	118	2.3
Ramanathapuram	10.7	6.70	2.4	103	2.7
Madurai	10.4	6.65	2.4	140	10.4
Arupukottai	9.9	6.65	2.4	138	7.8
Anamalai WLS	10.1	6.80	2.1	125	1.4
Aliyar	9.7	6.90	2.3	137	1.0
Coimbatore	10.6	7.90	2.3	143	9.0
Mettupalayam	9.8	6.60	2.2	111	3.1
Erode	9.7	7.10	2.5	116	5.7
Salem	10.1	6.95	1.9	115	5.6
Chinglepet	9.4	6.65	2.6	142	2.4
Trichy	8.4	7.00	2.2	103	15.8
Mean	9.76	6.89	2.3	124	5.6
SEd	NS	0.271	0.100	0.10	0.148
CD (0.05)	NS	0.541	0.200	0.21	0.295

iv. Individual seed weight

The weight of individual seed exhibited significant difference among different seed sources (Table 3). The seed weight was more in samples from Coimbatore (143 mg) which was on par with seeds from Chinglepet (142 mg). The lowest seed weight was recorded by Trichy and Ramanthapuram (103 mg). The average individual seed weight was 124 mg.

v) Insect damaged seed

The seed sources showed significant variation for the insect damaged seeds. The average insect damage for seed collected from different sources was 5.6 per cent (Table 3). The lowest insect damage was recorded in Aliyar (1 per cent) which was followed by Anamalai WLS (1.4 per cent). More insect damage was recorded in Trichy (15.8 per cent) which was followed by Madurai (10.4 per cent).

4.2.2. Assessment of germination, seedling growth and biomass under nursery conditions at two months after sowing**i. Germination**

Germination showed significant variation among seed sources. The average germination irrespective of seed sources was 80 per cent. The germination was higher in Tirunelveli (94 per cent) which was on par with Anamalai WLS (91 per cent). The next best source was Mettupalayam (90 per cent). The germination was less in Trichy (60 per cent) (Table 4).

ii. Root length

Seed sources showed significant variation for the root length. Seedlings raised from Coimbatore seed source recorded longer root (32.2 cm). The other sources showing better root length were Aliyar (27.5 cm), Mettupalayam (25.8 cm) and Anamalai WLS (25.3 cm). Trichy (15.6 cm) recorded the shortest root length (Table 4).

iii. Shoot length

Seed sources showed significant variation for shoot length of the seedlings. The average shoot length for different seed sources was 12.29 cm. The shoot length was found to be more in Arupukottai (21.1 cm) which was followed by Tirunelveli (16.1 cm). Trichy source measured the shortest shoot length (7.8 cm) (Table 4).

iv. Shoot collar diameter

The shoot collar diameter varied significantly among different seed sources (Table 4). The shoot collar diameter was more in Tirunelveli, Ramanathapuram and Aliyar (0.4 cm), while it was less in Erode and Trichy (0.2 cm).

v. Number of leaves

Number of leaves varied significantly among seed sources. The average number of leaves was 18.3. Arupukottai source registered more number of leaves (23.6) which was on par with Aliyar (20.4) and Coimbatore (20.2). While less number of leaves was registered in Erode (15.6) (Table 4).

vi. Number of nodules

Nodule number varied significantly among seed sources (Table 4). More number of nodules was observed from Madurai seed source (34.4) which was followed by Coimbatore (33.6). Number of nodules was less in Trichy seed source (7.2).

vii. Root and shoot fresh weights

Seed sources showed significant variations for the root and shoot fresh weights. The average root and shoot fresh weights were 6.95 and 9.87 g seedling⁻¹. The root and shoot fresh weights were more in Arupukottai (9.52 g seedling⁻¹) and

Table 4. Assessment of germination, seedling growth and biomass in different seed sources under nursery conditions at two months after sowing

Seed source	Germination (%) at 28 days after sowing	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of Nodules	Root fresh weight (g seedling ⁻¹)	Shoot fresh weight (g seedling ⁻¹)	Root dry weight (g seedling ⁻¹)	Shoot dry weight (g seedling ⁻¹)	Total dry weight (g seedling ⁻¹)
Tirunelveli	94.0 (76.32)	23.6	16.1	0.4	16.4	14.0	7.92	11.8	2.79	4.25	7.04
Ramanathapuram	87.0 (68.63)	22.3	13.6	0.4	16.6	11.2	6.91	10.32	2.23	3.69	5.92
Madurai	82.0 (64.67)	24.7	14.6	0.3	18.8	34.4	7.51	12.17	2.24	3.73	5.79
Arupukottai	80.0 (63.20)	23.0	21.1	0.3	23.6	28.4	9.52	8.56	2.93	6.62	9.55
Anamalai WLS	91.0 (72.72)	25.3	10.8	0.3	18.4	18.4	5.83	8.33	1.91	2.78	4.69
Aliyar	76.0 (60.90)	27.5	13.7	0.4	20.4	21.4	8.91	13.44	3.02	4.49	7.51
Coimbatore	79.0 (62.97)	32.2	13.6	0.3	20.2	33.6	8.98	14.28	2.81	4.38	7.19
Metupalayam	90.0 (71.63)	25.8	10.0	0.3	17.4	21.8	4.92	8.32	1.71	2.62	4.33
Erode	87.0 (69.22)	20.0	11.7	0.2	15.6	20.0	8.75	9.29	1.81	3.25	5.06
Salem	68.0 (55.36)	24.8	12.3	0.3	18.0	14.6	6.68	10.52	2.34	3.51	5.85
Chinglepet	64.0 (53.35)	22.0	9.8	0.3	17.2	14.0	4.49	6.64	1.33	2.08	3.41
Trichy	60.0 (50.77)	15.6	7.8	0.2	17.4	7.2	3.03	4.84	1.06	1.52	2.58
Mean	80.0 (64.16)	23.91	12.29	0.3	18.3	19.9	6.95	9.87	2.18	3.58	5.76
SED	1.67	3.68	1.68	0.031	2.06	6.52	0.23	0.05	0.15	0.04	0.19
CD (P=0.05)	3.45	7.41	3.38	0.060	4.15	13.12	0.46	0.30	0.19	0.08	0.18

(Figures in parentheses indicate arc sine transformed values)

Coimbatore (14.28 g seedling⁻¹) respectively. While Trichy recorded less root and shoot fresh weights of 3.03 and 4.84 g seedling⁻¹ respectively (Table 4).

viii. Root and shoot dry weights

Variations were found to be significant among seed sources for root and shoot dry weights. Aliyar on par with Arupukottai recorded more root dry weight (3.02 and 2.93 g seedling⁻¹). While Trichy recorded less root dry weight (1.06 g seedling⁻¹). Shoot dry weight was more in Arupukottai (6.62 g seedling⁻¹) and less in Trichy (1.52 g seedling⁻¹) (Table 4).

ix. Total dry weight

Total dry weight of the seedling showed significant variation among seed sources (Table 4). The total dry weight of the seedling was more in Arupukottai (9.55 g seedling⁻¹). The next best source was Aliyar (7.51 g seedling⁻¹). Trichy source registered less total dry weight of 2.58 g seedling⁻¹.

4.2.3. Assessment of seedling growth and biomass under nursery conditions at four months after sowing

i. Root length

Seedlings raised from Coimbatore seeds had the longest root length of 49.0 cm which was on par with Madurai (44.6 cm), Arupukottai (43.3 cm), Tirunelveli (42.7 cm) and Aliyar (42.7 cm). The root of seedling from Trichy (21.2 cm) and Chinglepet (29.2 cm) were shorter (Table 5).

ii. Shoot length

Seedlings from Arupukottai (27.8 cm) recorded longer shoot which was followed by Madurai (26.4 cm), Salem (26.0 cm) and Coimbatore (25.2 cm). Whereas shorter shoot length was recorded by Ramanthapuram (18.5 cm) (Table 5).

iii. Shoot collar diameter

Shoot collar diameter was more in Aliyar and Tirunelveli (0.9 cm) and they were on par with Arupukottai (0.8 cm). The shoot collar diameter was less in Anamalai WLS and Salem (0.5 cm) (Table 5).

iv. Number of leaves

Number of leaves varied significantly among the seed sources. More number of leaves was registered in the seedlings obtained from Arupukottai (28.7) which was on par with Coimbatore (27.0). The number of leaves in Anamalai WLS and Aliyar were 24.6 and 23.7 respectively. It was less in Ramanthapuram (17.3) (Table 5).

v. Number of nodules

Seedlings raised from Coimbatore recorded more number of nodules (37.3). Whereas Madurai (33.3) and Arupukottai (31.0) were the next best sources. The nodule number was the lowest (15.7) in Ramanathapuram (Table 5).

vi. Root and shoot fresh weights

Seed sources showed significant variations for root and shoot fresh weights. Among the seed sources, Arupukottai (10.16 g seedling⁻¹) followed by Coimbatore (9.28 g seedling⁻¹) and Aliyar (9.16 g seedling⁻¹) recorded more root fresh weight. While seedling from Trichy recorded less root fresh weight (6.27 g seedling⁻¹) (Table 5).

Seedlings from Coimbatore (15.48 g seedling⁻¹) showed more shoot fresh weight. The shoot fresh weight was less in Chinglepet (8.68 g seedling⁻¹) (Table 5).

Table 5. Assessment of seedling growth and biomass in different seed sources under nursery conditions at four months after sowing

Seed source	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of nodules	Root fresh weight (g seedling ⁻¹)	Shoot fresh weight (g seedling ⁻¹)	Root dry weight (g seedling ⁻¹)	Shoot dry weight (g seedling ⁻¹)	Total dry weight (g seedling ⁻¹)
Tirunelveli	42.7	20.8	0.9	18.0	18.7	8.42	14.27	4.54	5.37	10.12
Ramanathapuram	34.2	18.5	0.7	17.3	15.7	7.18	11.89	2.84	4.22	7.05
Madurai	44.6	26.4	0.6	22.7	33.3	8.06	13.64	3.48	4.72	8.19
Arupukottai	43.3	27.8	0.8	28.7	31.0	10.16	10.23	4.25	7.09	11.34
Anamalai WLS	36.3	21.8	0.5	24.6	24.3	6.83	9.75	2.92	5.80	8.72
Aliyar	42.7	23.7	0.9	23.7	25.7	9.16	12.79	3.59	6.07	9.65
Coimbatore	49.0	25.2	0.7	27.0	37.3	9.28	15.48	3.29	7.57	10.86
Mettupalayam	36.7	23.3	0.7	22.7	26.0	7.59	11.61	3.21	4.53	7.74
Erode	33.0	23.7	0.6	20.0	24.0	8.96	10.61	2.18	4.03	6.20
Salem	31.2	26.0	0.5	19.7	19.0	7.21	9.81	2.74	3.18	5.65
Chinglepet	29.2	19.2	0.7	18.0	22.0	6.84	8.68	2.81	2.81	5.62
Trichy	21.2	19.8	0.7	20.0	16.3	6.27	9.15	3.06	3.02	6.08
Mean	37.0	23.0	0.7	21.9	24.4	8.00	11.48	3.24	4.87	8.10
SEd	1.94	1.55	0.09	1.34	1.44	0.060	0.184	0.091	0.075	0.173
CD (P=0.05)	3.99	3.20	0.20	2.77	2.97	0.124	0.380	0.188	0.154	0.358

vii. Root and shoot dry weights

Seed sources showed significant differences for root and shoot dry weights. Root dry weight was more in Tirunelveli source (4.54 g seedling⁻¹), whereas it was less in Erode (2.18 g seedling⁻¹) (Table 5).

The shoot dry weight was more in Coimbatore source (7.57 g seedling⁻¹) while it was less in Chinglepet (2.81 g seedling⁻¹) (Table 5).

viii. Total dry weight

Significant variation was noticed among seed sources for seedling total dry weight. The total dry weight was more in Arupukottai (11.34 g seedling⁻¹) which was followed by Coimbatore (10.86 g seedling⁻¹). While Chinglepet (5.62 g seedling⁻¹) registered less total drymatter production and it was on par with Salem (5.65 g seedling⁻¹) (Table 5).

4.2.4. Assessment of seedling growth and biomass under nursery conditions at six months after sowing**i. Root length**

Root length of seedlings showed significant variation among seed sources. Among the seed sources, Coimbatore (49.47 cm) measured the longest root. Which was followed by Madurai (47.63 cm). The root length was shorter in Trichy source (28.77 cm) (Table 6).

ii. Shoot length

Significant variation was noticed among seed sources for the shoot length of the seedlings. Seedlings from Arupukottai measured the longest shoot (31.57 cm) which was on par with Salem (31.37 cm). Ramanathapuram recorded the shortest shoot of 20.80 cm (Table 6).

iii. Shoot collar diameter

The shoot collar diameter of the seedlings varied significantly among seed sources. It ranged from 0.5 to 0.9 cm. The collar diameter of the seedlings from Tirunelveli, Aliyar and Chinglepet recorded higher value (0.9 cm), while Salem recorded lower value (0.5 cm) (Table 6).

iv. Number of leaves

Significant variations were recorded among the seed sources for the number of leaves per seedling. Arupukottai seed source registered more number of leaves (32.0) which was on par with Coimbatore (31.3) source. The next best sources were Aliyar (27.3) and Madurai (27.0) which were on par with each other. Less number of leaves were noticed in seeds of Ramanathapuram (20.0) and Chinglepet (21.3) (Table 6).

v. Number of nodules

Number of nodules showed significant variations among seed sources. Coimbatore seed source performed better recording more number of nodules (40.3). Maduari and Arupukottai recorded 34.3 and 32.3 respectively which were on par with each other. The number of nodules was less for the seeds collected from Ramanathapuram (17.3) (Table 6).

vi. Root and shoot fresh weights

Root and shoot fresh weights were found to show significant difference for seed sources. Among seed sources, Arupukottai ($11.23 \text{ g seedling}^{-1}$) recorded more root fresh weight, while seedlings from Chinglepet and Anamalai WLS ($7.46 \text{ g seedling}^{-1}$) recorded less fresh weight (Table 6).

Table 6. Assessment of seedling growth and biomass in different seed sources under nursery conditions at six months after sowing

Seed sources	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of nodules	Root fresh weight (g seedling ⁻¹)	Shoot fresh weight (g seedling ⁻¹)	Root dry weight (g seedling ⁻¹)	Shoot dry weight (g seedling ⁻¹)	Total dry weight (g seedling ⁻¹)
Tirunelveli	46.47	23.07	0.9	22.3	20.7	9.10	17.14	6.40	6.62	13.02
Ramanathapuram	37.60	20.80	0.7	20.0	17.3	8.45	12.36	3.47	4.85	8.33
Madurai	47.63	28.17	0.6	27.0	34.3	8.78	15.55	4.79	5.69	10.48
Arupukottai	45.67	31.57	0.8	32.0	32.3	11.23	11.30	4.59	7.26	11.85
Anamalai WLS	39.43	24.97	0.7	26.0	26.0	7.46	10.58	3.79	6.67	10.46
Aliyar	43.67	27.70	0.9	27.3	29.0	10.29	13.69	4.15	6.51	10.65
Coimbatore	49.47	30.67	0.7	31.3	40.3	10.51	15.32	3.58	8.14	11.73
Mettupalayam	38.33	24.67	0.8	25.3	28.0	8.22	12.17	3.84	5.22	9.06
Erode	35.80	26.50	0.6	23.0	28.7	9.51	11.35	3.22	5.16	8.38
Salem	32.33	31.37	0.5	21.7	22.7	8.13	10.10	3.36	4.73	8.09
Chinglepet	30.60	21.30	0.9	21.3	24.7	7.46	9.74	4.20	3.68	7.88
Trichy	28.77	22.77	0.8	24.7	18.7	7.52	9.53	3.96	3.42	7.39
Mean	39.65	26.13	0.8	25.2	26.9	8.89	12.40	4.11	5.66	9.78
SEd	0.430	0.571	0.05	1.55	2.03	0.096	0.067	0.044	0.048	0.071
CD (P=0.05)	0.886	0.766	0.10	3.20	4.18	0.199	0.139	0.090	0.098	0.146

Tirunelveli source (17.14 g seedling⁻¹) recorded more shoot fresh weight and it was low in Trichy (9.53 g seedling⁻¹) (Table 6).

vii. Root and shoot dry weights

Root and shoot dry weights varied significantly among seed sources. More root dry weight was recorded from Tirunelveli source (6.40 g seedling⁻¹) and less in Erode source (3.22 g seedling⁻¹) (Table 6).

Arupukottai seed source recorded more shoot dry weight (7.26 g seedling⁻¹), whereas it was less in Trichy source (3.42 g seedling⁻¹) (Table 6).

viii. Total dry weight

Total dry weight showed significant difference among seed sources. Among seed sources, barring Erode, Ramanathapuram, Salem, Chinglepet and Trichy, all other seed sources recorded significantly higher total dry weight. The average total dry weight was 9.78 g seedling⁻¹. Tirunelveli seed source recorded more dry weight (13.02 g seedling⁻¹) which was followed by Arupukottai and Coimbatore (11.85 and 11.73 g seedling⁻¹, respectively) (Table 6).

4.2.5. Effect of seed source on survival and establishment of seedlings in the field at three months after planting

i. Survival

The average survival percentage irrespective of seed sources was 87. Seedling survival was higher in Coimbatore seed source (93 per cent). Erode (90 per cent) and Tirunelveli (89 per cent) were the other sources which recorded better survival. Ramanathapuram seed source recorded lower survival of 83 per cent and it was on par with Arupukottai (84 per cent) and Trichy (85 per cent) (Table 7).

ii. Plant height

The taller plant of 48.0 cm was recorded in Mettupalayam source which was on par with Aliyar (47.6 cm). The plant height from Chinglepet, Trichy and Salem were shorter (31.3, 29.7 and 29.5 cm respectively) and they were on par with each other (Table 7).

iii. Shoot collar diameter

Shoot collar diameter was more in Anamalai WLS (0.71 cm), whereas it was less in Arupukottai source (0.52 cm) (Table 7).

iv. Number of leaves

Number of leaves was more in Ramanathapuram source (5.7) and it was on par with Anamalai WLS (5.3) and Coimbatore (5.0). Tirunelveli and Erode registered less number of leaves (3.3 and 3.7 respectively) (Table 7).

4.3. STANDARDIZATION OF SEED TESTING PROCEDURES**4.3.1. Standardization of sample size for submitted and working samples**

The weight of the working sample from different seed sources was calculated as per ISTA (1993) rules. The average weight of 2500 seeds among seed sources was 276.15 g. Among seed lots it varied from 232.43 g (Ramanathapuram) to 338.12 g (Coimbatore). The weight of the submitted sample arrived at was 2760 g or 2.760 kg, (ten times the size of working sample) (Table 8).

4.3.2. Standardization of purity analysis

The pure seed fraction differed significantly for the seed lots (Table 9). The average pure seed was 99.1 per cent. Higher percentage of pure seed (99.7 per cent) was

Table 7. Performance of different seed sources of *A. lebbek* seedlings in the field at three months after planting

Seed source	Survival (%)	Plant height (cm)	Shoot collar diameter (cm)	Number of leaves
Tirunelveli	89 (70.7)	45.2	0.63	3.3
Ramanathapuram	83 (65.6)	39.6	0.57	5.7
Madurai	86 (68.3)	44.2	0.57	4.0
Arupukottai	84 (66.5)	44.6	0.52	4.3
Anamalai WLS	86 (68.3)	35.6	0.71	5.3
Aliyar	88 (69.7)	47.6	0.56	4.3
Coimbatore	93 (75.0)	37.5	0.57	5.0
Mettupalayam	86 (68.3)	48.0	0.53	4.3
Erode	90 (71.6)	46.9	0.86	3.7
Salem	86 (68.3)	29.5	0.56	4.0
Chinglepet	87 (69.2)	31.3	0.60	4.0
Trichy	85 (66.9)	29.7	0.54	4.7
Mean	87 (69.2)	40.0	0.60	4.3

SEd	1.2	0.91	0.012	0.45
CD (P=0.05)	2.4	1.87	0.025	0.93

(Figures in parentheses indicate arc sine transformed values)

Table 8 Standardization of sample size and weight for *A. lebbek*

Seed lot	100 seed weight (g)	1000 seed weight (g)	Weight of working sample size (g) (2500 seeds)	Submitted sample size (g)
Tirunelveli	9.977	99.77	282.29	2822.9
Ramanathapuram	9.537	95.37	232.43	2324.3
Madurai	11.708	117.08	276.06	2760.6
Arupukottai	11.841	118.41	272.82	2728.2
Anamalai WLS	8.018	80.18	295.60	2956.0
Aliyar	11.574	115.74	291.86	2918.6
Coimbatore	13.500	135.00	338.11	3381.1
Mettupalayam	9.494	94.94	235.71	2357.1
Erode	11.400	114.00	287.02	2870.2
Salem	10.041	100.41	254.24	2542.4
Chinglepet	12.888	128.88	314.02	3140.2
Trichy	9.351	93.51	233.65	2336.5
Mean	10.776	107.76	276.15	2761.5
CV	2.15	21.5		
SD	0.23	2.14		
SEd			6.057	60.57
CD (P=0.05)			12.115	121.15

Table 9. Standardization of purity analysis in *A. lebbek*

Seed lot	Pure seed (%)	Inert matter (%)
Tirunelveli	99.5	0.5
Ramanathapuram	98.5	1.5
Madurai	99.7	0.3
Arupukottai	99.4	0.6
Anamalai WLS	99.6	0.4
Aliyar	99.6	0.4
Coimbatore	99.0	1.0
Mettupalayam	99.2	0.8
Erode	98.3	1.7
Salem	99.1	0.9
Chinglepet	98.4	1.6
Trichy	98.3	1.7
Mean	99.1	0.9
SEd	0.22	0.17
CD (P=0.05)	0.43	0.34

recorded in seed lots from Madurai which was on par with Anamalai WLS and Aliyar (99.6 per cent each). The pure seed fraction was lower in seed lots from Trichy (98.3 per cent), Erode (98.3 per cent) and Chinglepet (98.4 per cent) which were on par with each other.

The seed lots from various seed sources showed significant variations for inert matter (Table 9). The inert matter was more (1.7 per cent) each in Trichy and Erode which was on par with Chinglepet (1.6 per cent). The least percentage of inert matter was recorded in Madurai seed lot (0.3 per cent).

4.3.3. Standardization of hundred seed weight

The seed lots collected from different seed sources displayed significant difference for 100 seed weight (Table 8). The mean 100 seed weight was 10.776 g. The 100 seed weight was higher in Coimbatore (13.500 g) followed by Chinglepet (12.888 g). It was less in Anamalai WLS (8.018 g). The standard deviation calculated was below 4.0 (SD value of present study was 0.23), and therefore confirms to ISTA (1993) standards.

4.3.4. Standardization of germination test requirements

4.3.5.1. Standardization of pretreatments to break seed dormancy

1. Acid scarification

The germination differed significantly among different durations of acid scarification. There was a significant increase in germination as the duration of scarification increases upto 30 min. and thereafter it decreased. The higher germination of 88.3 per cent was obtained at 30 min. acid scarification which was followed by 25 min. (81.8 per cent). A germination of 26.5 per cent was recorded in unscarified control (Table 10).

The longest root of 13.0 cm and shoot of 11.3 cm were recorded at 35 min. and 15 min. scarification, respectively (Table 10).

Seeds scarified for 25 min. recorded higher vigour index (1886), while higher drymatter production was recorded with 30 min. scarification (0.241 g seedling⁻⁵) (Table 10).

2. Combination of acid scarification and GA₃

Seed germination of *Albizia lebbek* expressed significant variation among seed lots, treatments and their interactions. Among the treatments, scarification with H₂SO₄ 25 min + 24 h water soaking recorded higher germination (73 per cent) irrespective of the seed sources. The next best treatments were acid scarification followed by GA₃ 200 ppm soaking for 24 h (70.6 per cent) and acid scarification followed by GA₃ 100 ppm soaking for 24 h (69.2 per cent). Irrespective of the treatments, Erode (73.8 per cent) recorded higher germination and it was on par with Aliyar (73.3 per cent). These were followed by Madurai (71.7 per cent). Seeds from Trichy source registered lower germination of 55.6 per cent. The interaction between seed sources and treatments showed that seeds from Aliyar given with H₂SO₄ 25 min. followed by 24 h water soaking recorded the highest seed germination of 83.5 per cent (Table 11).

3. Standardization of suitable growth regulator

i. Germination

GA₃

Both seed lots and treatments and also their interactions were significant for germination. Among the different concentrations of GA₃, germination was enhanced at 200 ppm (69.9 per cent), and further increase in ppm levels decreased the germination. Among the seed lots, higher seed germination was registered in Aliyar (76.6 per cent).

Table 10. Standardization of dormancy breaking pre-treatments in *A. lebbek* - Acid scarification

Duration of acid scarification	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index	Drymatter production (g seedlings ⁻⁵)
0 min	26.5 (30.9)	10.5	9.4	528	0.120
5 min	46.5 (42.9)	12.6	10.0	1049	0.118
10 min	55.7 (48.3)	10.7	8.9	1091	0.108
15 min	64.8 (53.6)	9.4	11.3	1336	0.117
20 min	77.5 (61.7)	11.9	9.8	1678	0.165
25 min	81.8 (64.7)	12.3	10.8	1886	0.221
30 min	88.3 (69.9)	12.2	8.4	1818	0.241
35 min	69.5 (56.4)	13.0	9.3	1543	0.212
Mean	63.8 (53.6)	11.6	9.7	1366	0.163
SEd	1.11	0.55	0.51	49.2	0.005
CD (P=0.05)	2.29	1.13	1.06	101.5	0.011

(Figures in parentheses indicate arc sine transformed values)

Table 11. Standardization of dormancy breaking pre-treatments in *A. lebbek* - Combination of acid scarification and GA₃

Germination (%)

Seed lot (L)	Treatments (T)										Mean
	T ₀	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉	
Tirunelveli	53.0 (46.7)	62.5 (52.2)	74.5 (59.6)	70.5 (57.1)	67.0 (54.9)	64.5 (53.4)	71.0 (57.4)	67.5 (55.2)	66.3 (54.6)		
Ramanathapuram	57.0 (49.0)	76.5 (61.2)	81.0 (64.1)	72.5 (58.0)	63.5 (52.8)	61.5 (51.6)	69.5 (56.4)	63.5 (52.8)	68.1 (55.8)		
Madurai	46.0 (42.7)	77.0 (61.3)	76.5 (61.0)	76.5 (61.0)	77.0 (61.3)	75.0 (60.0)	74.5 (59.6)	71.0 (57.4)	71.7 (58.1)		
Arupukottai	40.5 (39.5)	68.5 (55.9)	74.0 (59.3)	70.5 (57.1)	66.5 (54.6)	67.0 (54.9)	69.0 (56.1)	66.0 (54.3)	65.3 (53.9)		
Anamalai WLS	42.5 (40.7)	67.0 (54.9)	70.5 (57.1)	66.0 (54.3)	69.0 (56.1)	67.5 (55.2)	69.5 (56.4)	68.0 (55.5)	65.0 (53.8)		
Aliyar	44.5 (41.8)	78.5 (62.3)	83.5 (66.0)	73.0 (58.7)	76.5 (61.0)	74.5 (59.6)	78.0 (62.0)	77.5 (61.6)	73.3 (59.2)		
Coimbatore	37.5 (37.8)	68.5 (55.8)	70.5 (57.1)	69.0 (56.1)	76.0 (60.6)	73.5 (59.0)	76.0 (60.6)	71.5 (57.7)	67.8 (55.6)		
Mettupalayam	34.5 (35.9)	63.5 (52.8)	68.5 (55.8)	73.0 (58.6)	65.5 (54.0)	66.5 (54.6)	71.0 (57.4)	68.5 (55.8)	63.9 (53.2)		
Erode	54.5 (47.5)	79.0 (62.7)	82.0 (64.9)	72.0 (58.0)	77.5 (61.6)	76.0 (60.6)	75.0 (60.0)	74.0 (59.3)	73.8 (59.4)		
Salem	33.0 (35.0)	57.0 (49.0)	64.0 (53.1)	61.5 (51.6)	65.5 (54.0)	67.0 (54.9)	68.5 (55.8)	66.0 (54.3)	60.3 (51.0)		
Chinglepet	31.5 (34.1)	64.0 (53.4)	69.5 (56.4)	61.0 (51.3)	65.5 (54.0)	64.0 (53.1)	64.5 (53.4)	61.0 (51.3)	60.2 (50.9)		
Trichy	29.5 (32.8)	57.0 (49.0)	61.0 (51.3)	59.0 (50.1)	61.0 (51.3)	59.0 (50.4)	60.5 (51.0)	57.0 (49.3)	55.6 (48.2)		
Mean	42.0 (40.3)	68.3 (55.9)	73.0 (58.9)	68.7 (56.0)	69.2 (56.4)	68.0 (55.6)	70.6 (55.2)	67.7 (54.5)			

SEd

CD (P=0.05)

L L x T

0.42 1.18

0.83 2.36

T

0.34

0.68

(Figures in parentheses indicate arc sine transformed values)

Next best lots were Erode (73.8 per cent), Coimbatore (72.9 per cent) and Madurai (72.3 per cent). The lower germination was registered by Trichy (61.1 per cent). The interaction effect showed that seed germination was higher from Aliyar at GA₃ 400 ppm (78.7 per cent) (Table 12).

IAA

The differences among seed lots and IAA concentrations were significant for seed germination. Seeds soaked in IAA 200 ppm (81.6 per cent) followed by IAA 100 ppm (77.1 per cent) enhanced the seed germination. While 500 ppm recorded only 68.9 per cent germination. Among the seed lots, higher germination was registered in Coimbatore (81.8 per cent) and it was on par with Aliyar (81.4 per cent). Whereas lower germination was recorded in Trichy (68.9 per cent). The interaction between seed lot and IAA concentration revealed that Coimbatore at IAA 200 ppm recorded more germination of 90.3 per cent. Whereas it was less in Anamalai WLS at IAA 500 ppm (62 per cent) (Table 12).

IBA

With respect to seed soaking with IBA, increased germination was obtained for IBA 200 ppm (75.0 per cent) which was followed by IBA 300 ppm (69.9 per cent). Aliyar gave better germination (78.3 per cent) which was on par with Madurai (78.0 per cent). The next best lot was Arupukottai (76.8 per cent). Trichy registered lower value of 60.6 per cent. The interaction effect showed that Madurai at IBA 200 ppm (85.0 per cent) recorded higher seed germination. Whereas it was lower from Chinglepet seed soaked in IBA 500 ppm (58.6 per cent) (Table 12).

Table 12. Standardization of a suitable growth regulator - Germination (%)

Seed lot (L)	3-Axial Time				5-Axial Time				BRAJ Time				Mean
	180	200	300	400	180	200	300	400	180	200	300	400	
Tirunelveli	55.6	71.7	70.7	69.7	88.3	85.3	76.6	71.6	55.6	74.3	54.6	67.5	53.0
	(48.2)	(55.7)	(57.2)	(56.6)	(63.6)	(67.5)	(62.1)	(57.8)	(48.2)	(54.7)	(56.5)	(55.1)	(52.5)
	57.0	65.3	65.3	61.3	78.6	82.0	76.7	73.0	57.0	71.6	68.0	70.7	58.0
	(49.0)	(55.1)	(53.9)	(57.6)	(62.4)	(64.2)	(61.1)	(58.7)	(49.0)	(57.8)	(55.5)	(57.2)	(55.5)
Ramanathapuram	40.5	76.3	71.3	72.0	75.7	80.6	79.3	74.0	40.5	78.3	79.0	74.0	78.0
	(39.5)	(69.9)	(58.9)	(58.1)	(60.4)	(63.9)	(62.9)	(59.3)	(39.5)	(62.2)	(62.7)	(57.3)	(59.1)
	44.5	69.3	69.3	68.3	78.7	83.6	82.3	79.3	44.5	77.0	76.7	80.3	75.6
	(41.8)	(56.4)	(56.4)	(55.8)	(62.4)	(66.1)	(65.1)	(62.7)	(41.8)	(57.4)	(60.4)	(63.6)	(60.3)
Anamalai WLS	46.5	68.0	69.0	65.7	66.3	75.6	72.6	71.0	46.5	68.3	65.6	68.3	64.3
	(42.7)	(55.6)	(55.5)	(54.1)	(54.5)	(60.4)	(58.4)	(57.4)	(42.7)	(53.9)	(53.7)	(55.7)	(53.3)
	48.0	78.3	76.6	78.7	82.6	88.3	81.3	78.0	48.0	80.0	84.6	76.7	78.3
	(43.5)	(62.3)	(61.1)	(62.5)	(64.4)	(70.0)	(64.3)	(62.0)	(43.5)	(63.4)	(66.9)	(61.1)	(60.2)
Combarare	59.0	75.7	74.7	74.3	85.6	90.3	83.0	76.7	59.0	80.3	76.7	75.0	69.3
	(50.1)	(60.4)	(59.8)	(57.6)	(67.3)	(71.9)	(65.6)	(61.1)	(50.1)	(58.4)	(61.6)	(60.9)	(56.3)
	60.2	67.3	69.3	70.3	72.9	72.9	80.0	77.7	60.2	73.0	67.3	62.3	64.0
	(51.0)	(55.1)	(56.4)	(57.0)	(61.5)	(63.6)	(63.4)	(61.8)	(51.0)	(58.7)	(53.1)	(52.1)	(54.3)
Metupalayam	55.4	76.7	73.0	73.3	80.3	79.0	77.0	72.6	55.4	83.0	76.3	67.6	63.6
	(48.2)	(61.1)	(60.4)	(58.9)	(63.6)	(62.7)	(61.3)	(58.4)	(48.2)	(59.8)	(60.9)	(54.9)	(58.8)
	48.0	65.0	67.7	65.6	76.6	81.3	75.0	69.6	48.0	66.0	69.7	62.7	60.6
	(43.6)	(53.7)	(55.3)	(54.1)	(61.1)	(64.4)	(60.0)	(56.5)	(43.6)	(54.3)	(53.3)	(52.3)	(51.1)
Salem	42.0	63.3	64.3	61.3	71.0	75.3	68.7	70.0	42.0	62.7	66.0	61.3	58.6
	(40.4)	(52.7)	(53.3)	(51.6)	(57.4)	(60.2)	(55.9)	(56.7)	(40.4)	(52.3)	(54.3)	(51.1)	(49.9)
	41.0	62.0	61.3	61.3	72.6	77.3	68.7	63.3	41.0	60.3	63.7	60.0	59.0
	(39.5)	(51.9)	(51.6)	(51.6)	(58.4)	(61.5)	(55.9)	(52.7)	(39.5)	(50.9)	(52.9)	(50.7)	(50.2)
Tiruchy	49.8	69.6	69.9	68.2	77.1	81.6	76.8	73.0	49.8	75.0	69.9	68.7	66.2
	(44.7)	(56.6)	(56.8)	(55.7)	(64.8)	(68.3)	(63.3)	(58.8)	(44.7)	(60.2)	(56.9)	(56.1)	(54.5)
	Mean												

SEd L G LxG LxG LxG L G LxG L G LxG L G LxG
 CD (P=0.05) 0.058 0.377 0.130 0.074 0.479 0.166 0.245 0.158 0.557 0.484 0.312 0.84 0.312 0.84

G - Growth regulator
 (Figures in parentheses indicate arc sine transformed values)

Among the three growth regulators, IAA 200 ppm registered the highest germination of 81.6 per cent which was followed by IAA 100 ppm (77.1 per cent). The third best treatment was IBA 200 ppm (75.0 per cent).

ii. Root length

GA₃

Significant variations were noticed for the root length among the seed lots and concentrations. The root was found to be lengthier at GA₃ 400 ppm (13.52 cm) which was 43 per cent increase over 100 ppm (9.48 cm). Among the seed lots, Coimbatore proved the best with lengthier root (13.58 cm) which was on par with Arupukottai (13.37 cm) and Madurai (13.36 cm). The interaction was also significant. Madurai which received GA₃ 400 ppm (18.13 cm) proved to be lengthier. Whereas shorter root was recorded with Erode seeds at GA₃ 100 ppm (7.20 cm) and this was on par with Anamalai WLS (7.23 cm) at GA₃ 200 ppm (Table 13).

IAA

Performance of root length at IAA 200 ppm was the best with 16.45 cm. While it was the shortest in IAA 500 ppm (10.43 cm). Among the seed lots, Mettupalayam on par with Coimbatore recorded longer root of 16.58 cm and 16.51 respectively. It was lower in Trichy (10.86 cm). The interaction effect showed that Mettupalayam seed at IAA 100 ppm registered longer shoot (22.40 cm) and it was shorter in Salem seed lot (8.80 cm) which received IAA 500 ppm (Table 13).

IBA

Root length was found to be more at lower levels of IBA viz., IBA 100 ppm (15.88 cm) and it reduced as the ppm level increases. Root length was found to be non significant for the seed lots and their interactions (Table 13).

Table 13. Standardization of a suitable growth regulator – Root length (cm)

Seed lot (L)	Control		GA ₃ (ppm)				IAA ₃ (ppm)				IBA ₃ (ppm)				Mean				
	100l	200l	300l	400l	500l	600l	100l	200l	300l	400l	500l	600l	100l	200l		300l	400l	500l	600l
Trunelveli	10.31	10.47	9.00	12.40	12.80	13.82	10.31	12.50	16.53	18.37	18.37	18.37	10.31	11.20	10.27	8.27	8.20	8.13	9.21
Ramanathapuram	11.00	10.17	13.77	15.73	15.23	13.90	11.30	10.67	13.07	16.30	16.30	16.30	10.31	10.43	8.90	10.17	9.20	9.33	9.63
Madurai	12.45	9.33	16.10	18.13	13.13	13.36	12.45	14.23	13.30	14.37	14.37	14.37	10.31	14.17	8.77	7.59	7.33	7.70	13.20
Arupukottai	13.20	10.47	15.50	16.17	15.10	13.37	13.20	15.23	14.16	19.33	16.30	16.30	10.31	14.36	5.47	7.16	7.00	7.00	10.37
Anamalai WLS	14.00	7.23	13.17	14.20	13.80	11.46	14.00	12.90	16.20	12.90	12.13	9.70	10.31	14.00	12.07	13.90	11.16	10.65	12.41
Aliyar	15.25	8.37	9.60	10.47	10.67	9.66	15.25	15.60	21.26	12.43	13.30	12.10	10.31	15.25	12.33	11.17	12.07	11.20	12.55
Coimbatore	11.36	13.80	15.27	12.70	13.73	13.58	11.36	21.10	18.20	20.37	12.43	10.43	10.31	11.36	16.83	12.86	11.90	11.87	13.36
Methupalayam	12.10	13.27	14.57	14.60	14.37	13.14	12.10	22.40	21.43	19.27	9.27	10.53	10.31	12.10	14.87	14.13	12.70	10.07	13.64
Erode	11.00	9.50	12.27	11.90	10.23	10.22	11.00	16.50	18.27	16.17	9.67	10.13	10.31	11.00	13.20	10.86	10.37	9.60	11.45
Salem	10.48	10.23	11.13	12.73	11.27	10.99	10.48	14.33	17.50	18.27	10.23	8.80	10.31	10.48	9.50	8.53	8.30	8.93	9.45
Chinglepet	11.10	8.47	11.33	12.73	11.27	10.42	11.10	10.26	12.57	10.43	13.53	12.23	10.31	11.10	8.87	9.37	10.07	9.03	10.09
Tiruchy	9.86	9.07	11.77	10.43	9.93	10.16	9.86	10.10	15.27	10.23	9.80	9.70	10.31	9.86	9.93	9.93	9.10	9.00	9.50
Mean	11.84	9.96	12.79	13.52	12.67	10.16	11.84	14.65	16.45	15.70	11.69	10.43	10.31	11.84	11.03	10.51	10.12	9.59	9.50

SEd
CD (P=0.05)

L G L x G
0.129 0.083 0.289
0.257 0.166 0.574

L G L x G
0.082 0.053 0.184
0.163 0.105 0.364

L G L x G
NS 1.630 NS
NS 3.227 NS

G – Growth regulator

Of all the three growth regulators, IAA 200 ppm resulted in longer root (16.45 cm) compared to IBA and GA₃ treatment at five different ppm levels.

iii. Shoot length

GA₃

The shoot was found to be more at lower ppm levels ie, GA₃ 100 ppm (7.25 cm) and reduced at higher levels. Among the seed lots, Trichy (9.43 cm) recorded longer shoot, while it was shorter in Erode source (5.42 cm). Their interactions showed that at GA₃ 200 ppm, Trichy (10.34 cm) and Ramanathapuram at GA₃ 400 ppm (4.40 cm) recorded the longest and shortest shoot, respectively (Table 14).

IAA

IAA 200 ppm (11.02 cm) followed by 300 ppm (10.16 cm) registered longer shoot compared to other ppm levels. The shoot length ranged from 6.55 cm (Tirunelveli) to 12.26 cm (Coimbatore) among seed lots. The interaction effect showed that Coimbatore seed soaked at IAA 200 ppm recorded longer shoot (15.23 cm). Whereas it was shorter in Tirunelveli seed soaked (5.23 cm) at IAA 400 ppm (Table 14).

IBA

Similar to IAA treatment, IBA also registered longer shoot (9.64 cm) at 200 ppm. At higher ppm levels a reduction in shoot length was noticed. Comparing the seed lots alone, longer shoot was measured in Coimbatore (10.35 cm) and it was on par with Salem (10.15 cm). It was the shortest in Tirunelveli (6.39 cm). The interactions showed that Madurai seed soaked in IBA 200 ppm recorded longer shoot of 11.43 cm. It was shorter in Tirunelveli seed soaked (5.60 cm) at IBA 500 ppm (Table 14).

Table 14. Standardization of a suitable growth regulator – Shoot length (cm)

Seed lot (L)	Control	GA ₃ (ppm)				Mean	Control	IAA (ppm)				Mean	Control	IBA (ppm)				Mean	
		100	200	300	400			500	100	200	300			400	500	100	200		300
Tirunelveli	7.25	8.06	8.03	5.13	4.90	4.43	7.25	7.56	7.63	6.93	5.23	5.37	7.25	6.50	6.56	7.13	6.17	5.69	6.3
Ramanathapuram	6.70	7.37	6.23	5.47	4.40	6.20	6.70	8.37	10.17	11.13	7.50	7.16	8.87	8.23	10.20	9.43	9.63	6.47	8.7
Madurai	7.10	5.30	7.16	6.17	5.43	5.03	7.10	9.36	12.50	10.07	9.27	8.16	9.87	9.13	11.43	8.47	10.20	9.13	9.6
Arupukottai	6.14	7.13	7.17	7.23	6.30	6.40	6.14	10.30	10.83	12.43	10.27	9.67	10.70	9.23	10.13	9.27	9.27	9.23	9.4
Anamalai WLS	5.90	6.26	6.33	6.13	7.53	6.63	5.90	11.20	9.67	9.13	10.20	7.53	9.54	8.16	9.63	9.17	6.70	10.01	8.7
Aliyar	6.18	6.06	6.17	5.96	5.23	5.33	6.18	8.3	13.50	10.50	8.47	8.17	9.77	9.56	10.20	10.20	9.97	9.50	9.8
Coimbatore	7.26	7.63	7.67	6.66	6.23	6.06	7.26	11.60	15.23	12.30	11.10	11.07	12.26	10.26	10.90	10.40	10.10	10.10	10.3
Mettupalayam	6.40	5.23	6.43	7.23	7.33	7.13	6.40	8.57	8.63	7.40	8.53	8.13	8.25	9.53	10.23	9.40	9.27	9.13	9.5
Erode	7.15	6.10	5.00	5.53	5.23	5.23	7.15	10.57	10.40	9.90	9.03	8.13	9.61	8.16	9.20	9.00	9.27	9.10	8.9
Salem	8.22	8.17	7.12	7.23	9.16	8.13	8.22	11.27	11.37	10.47	10.20	9.90	10.64	10.40	9.73	10.13	10.20	10.27	10.1
Chinglepet	9.60	10.17	8.23	8.30	6.16	5.40	9.60	10.37	12.17	11.33	9.37	9.07	10.46	8.67	8.30	8.27	8.10	8.23	8.31
Trichy	9.25	9.56	10.34	9.90	10.2	7.13	9.25	9.37	10.17	10.30	9.57	8.47	9.57	8.16	9.10	8.30	8.70	8.17	8.45
Mean	7.27	7.25	7.16	6.75	6.51	6.09	7.27	9.14	11.02	10.16	9.06	8.40	-	8.84	9.64	9.10	8.96	8.75	-

SEd
CD (P=0.05)

L G L x G
0.058 0.377 0.130
0.116 0.074 0.259

L G L x G
0.074 0.479 0.166
0.147 0.095 0.329

L G L x G
0.245 0.158 0.547
0.484 0.312 1.084

G – Growth regulator

Among the three growth regulators at five different ppm levels, IAA resulted in longer shoot (11.02 cm) at 200 ppm, while it was only 9.64 cm and 7.25 cm with IBA 200 ppm and GA₃ 100 ppm respectively.

iv. Vigour index

GA₃

The vigour index showed increasing trend from 1158 (GA₃ 100 ppm) to 1387 (GA₃ 400 ppm). At 500 ppm, a decrease in vigour index was observed. Among the seed lots, greater vigour index was recorded in Coimbatore (1461) which was followed by Arupukottai (1373). The lower vigour index was noticed in Chinglepet (1113). The interaction effect showed that at GA₃ 400 ppm, Madurai (1697) recorded higher vigour index (Table 15).

IAA

At IAA 200 ppm, the vigour index was higher (2217) and it reduced at IAA 500 ppm (1299). Among seed lots, the vigour index ranged from 1391 (Trichy) to 2336 (Coimbatore). The interaction effect showed that at 200 ppm Coimbatore recorded higher vigour index (3101). It was low with Mettupalayam at IAA 300 ppm (865) (Table 15).

IBA

IBA soaking performed better at 200 ppm (1558) for vigour index which reduced as the level increased upto 500 ppm, which recorded vigour index of 1220. Among the seed lots, Coimbatore recorded higher vigour index (1789) and it was on par with Aliyar (1766). Lower vigour index was noticed by Tirunelveli (1067). The interaction effect revealed that at IBA 100 ppm, higher vigour index was recorded in Aliyar (2051). Whereas it was lower in Tirunelveli at IBA 500 ppm from (866) (Table 15).

Table 15. Standardization of a suitable growth regulator – Vigour index

Seed lot (L)	Control	GA ₃ (ppm)				Mean	Control	IAA (ppm)				Mean	IBA (ppm)				Mean			
		100	200	300	400			500	100	200	300		400	500	100	200		300	400	500
		Tirunelveli	976	1196	1326			1000	1405	1177	976		1612	2028	1939	1030		1040	1529	1180
Ramanathapuram	1009	1141	1104	1239	1235	1257	1009	1488	1905	2103	1304	1125	1585	1226	1369	1333	1330	1675	1267	
Madurai	872	1137	1154	1579	1697	1282	872	1786	2081	1938	1746	1329	1776	1520	1709	1425	1452	1240	1469	
Arupukottai	865	1220	1162	1560	1535	1390	865	2008	2092	2615	2128	1509	2070	1690	1574	1413	1466	1425	1512	
Anamalai WLS	925	1031	923	1363	1441	1355	925	1599	1957	976	1585	1068	1562	1525	1483	1453	1426	1338	1445	
Aliyar	1029	1198	1119	1173	1188	1168	1029	1976	2892	1009	1698	1560	1998	2051	1908	1624	1689	1559	1766	
Coimbatore	1099	1516	1470	1613	1350	1359	1099	2802	3101	872	1804	1584	2336	1969	2022	1784	1650	1523	1789	
Mettupalayam	1114	929	1366	1509	1542	1426	1114	2394	2442	865	1382	1307	1928	1628	1832	1585	1369	1229	1528	
Erode	1006	1019	1097	1292	1256	1088	1006	2175	2218	925	1380	1224	1797	1599	1860	1517	1316	1190	1496	
Salem	898	1154	1177	1181	1565	1249	898	1963	2274	1029	1423	1252	1813	1478	1340	1199	1159	1165	1268	
Chinglepet	869	1169	1074	1160	1159	1005	869	1465	1794	1099	1566	1448	1553	1366	1138	1081	1108	1012	1141	
Trichy	784	1188	1192	1357	1266	1012	784	1415	1817	1114	1176	1139	1391	1122	1216	1040	1668	1013	1091	
Mean	954	1158	1180	1336	1387	1230	954	1890	2217	1374	1518	1299	-	1529	1558	1377	1333	1220	-	

SEd
CD (P=0.05)

L G L N G
23.2 14.9 51.9
45.9 29.6 102.8

L G L N G
14.8 9.6 33.2
29.4 19.0 65.8

G – Growth regulator

For this parameter, among three growth regulators, IAA 200 ppm outperformed others.

v. Drymatter production

Soaking of seeds separately in GA₃, IAA and IBA at 200 ppm each gave more drymatter production of 0.129, 0.182 and 0.143 g seedling⁻⁵ respectively. Beyond this level, a decrease in drymatter production was recorded. Among seed lots, Mettupalayam recorded higher drymatter production (0.137 g seedling⁻⁵). Drymatter production was less in Madurai (0.112 g seedling⁻⁵), Aliyar (0.122 g seedling⁻⁵) and Ramanathapuram (0.107 g seedling⁻⁵). The interaction effect between seed lots and growth regulators was significant. The drymatter was more in Arupukottai (0.197 g seedling⁻⁵) at GA₃ 200 ppm. Chinglepet performed better both for IAA and IBA at 200 ppm with 0.311 and 0.211 g seedling⁻⁵, respectively (Table 16).

Among the growth regulators and concentration, IAA 200 ppm resulted in more drymatter production (0.182 g seedling⁻⁵) compared to other treatments.

4. Infusion of growth regulators

i. Germination

Irrespective of seed lots, the seeds infused with GA₃ 100 ppm recorded higher germination (83.3 per cent) compared to kinetin 100 ppm (80.6 per cent) and control (76.5 per cent). Among seed lots, seeds from Aliyar (88.2 per cent) recorded more germination followed by Mettupalayam and Arupukottai (87.1 and 87.0 per cent, respectively). The interaction effect showed that higher germination was recorded by Tirunelveli (93.6 per cent) under GA₃ 100 ppm (Table 17).

Table 16. Standardization of a suitable growth regulator – Drymatter production (g seedlings⁻¹)

Seed lot (L)	Control	GA ₃ (ppm)				IAA (ppm)				IBA (ppm)				Mean										
		100	200	300	400	500	100	200	300	400	500	100	200		300	400	500							
		Control	Mean	Control	Mean	Control	Mean	Control	Mean	Control	Mean	Control	Mean		Control	Mean								
Tirunelveli	0.112	0.108	0.116	0.122	0.120	0.106	0.112	0.118	0.129	0.129	0.114	0.114	0.183	0.151	0.114	0.164	0.112	0.097	0.115	0.121	0.107	0.105	0.109	
Ramanathapuram	0.119	0.116	0.120	0.146	0.123	0.119	0.125	0.138	0.154	0.164	0.139	0.122	0.164	0.139	0.122	0.143	0.119	0.107	0.119	0.192	0.097	0.117	0.107	0.107
Madurai	0.108	0.106	0.111	0.117	0.118	0.113	0.112	0.118	0.137	0.154	0.123	0.114	0.154	0.123	0.114	0.129	0.108	0.076	0.122	0.125	0.117	0.111	0.110	0.110
Arupukottai	0.117	0.114	0.117	0.124	0.117	0.123	0.135	0.157	0.150	0.129	0.114	0.111	0.129	0.114	0.111	0.132	0.117	0.122	0.130	0.127	0.124	0.119	0.125	0.125
Anamalai WLS	0.105	0.104	0.128	0.141	0.128	0.120	0.125	0.162	0.166	0.140	0.125	0.121	0.140	0.125	0.121	0.143	0.105	0.155	0.159	0.154	0.161	0.126	0.151	0.151
Aliyar	0.120	0.120	0.110	0.118	0.122	0.114	0.117	0.115	0.146	0.126	0.116	0.105	0.126	0.116	0.105	0.122	0.120	0.125	0.131	0.120	0.112	0.113	0.120	0.120
Coimbatore	0.151	0.160	0.152	0.104	0.117	0.109	0.128	0.156	0.183	0.188	0.170	0.171	0.188	0.170	0.171	0.173	0.151	0.103	0.111	0.109	0.109	0.112	0.109	0.109
Mettupalayam	0.136	0.143	0.139	0.146	0.134	0.122	0.137	0.197	0.213	0.212	0.214	0.203	0.212	0.214	0.203	0.208	0.136	0.136	0.126	0.120	0.112	0.093	0.117	0.117
Erode	0.120	0.114	0.115	0.127	0.124	0.125	0.121	0.201	0.202	0.195	0.195	0.197	0.195	0.195	0.197	0.198	0.120	0.195	0.172	0.163	0.153	0.144	0.165	0.165
Salem	0.114	0.112	0.119	0.131	0.130	0.129	0.124	0.209	0.203	0.185	0.173	0.155	0.185	0.173	0.155	0.184	0.114	0.204	0.186	0.176	0.115	0.115	0.159	0.159
Chinglepet	0.130	0.138	0.135	0.149	0.115	0.118	0.131	0.253	0.311	0.292	0.262	0.211	0.292	0.262	0.211	0.266	0.130	0.218	0.211	0.204	0.130	0.125	0.177	0.177
Trichy	0.112	0.108	0.116	0.124	0.121	0.113	0.116	0.162	0.118	0.110	0.107	0.105	0.110	0.107	0.105	0.121	0.112	0.145	0.136	0.126	0.113	0.107	0.125	0.125
Mean	0.120	0.120	0.129	0.128	0.122	0.118	-	0.170	0.182	0.173	0.157	0.144	0.173	0.157	0.144	-	0.120	0.140	0.143	0.137	0.121	0.115	-	-

SEd
CD (P=0.05)

L G LxG L G LxG L G LxG L G LxG L G LxG

0.0007 0.0045 0.0015 0.0012 0.0007 0.0026 0.0032 0.0021 0.0073
0.0014 0.0091 0.0031 0.0023 0.0015 0.0053 0.0064 0.0042 0.0044

G – Growth regulator

Table 17. Effect of seed infusion with growth regulators on seed germination (%) of *A. lebbek*

Seed lot (L)	Treatments (T)			Mean
	Control	GA ₃	Kinetin	
Tirunelveli	75.6 (60.5)	93.6 (74.3)	85.3 (67.6)	84.5 (67.4)
Ramanathapuram	82.0 (64.9)	83.7 (66.2)	88.0 (69.8)	85.0 (66.9)
Madurai	80.0 (63.4)	85.0 (67.2)	56.6 (44.8)	73.8 (58.5)
Arupukottai	81.3 (64.4)	87.7 (69.5)	92.0 (73.6)	87.0 (69.2)
Anamalai WLS	80.0 (63.5)	88.0 (74.3)	91.0 (67.6)	86.3 (68.6)
Aliyar	84.3 (66.7)	91.3 (72.9)	89.0 (70.8)	88.2 (70.1)
Coimbatore	79.7 (63.2)	86.3 (68.3)	88.6 (70.4)	84.8 (67.3)
Mettupalayam	86.0 (68.1)	90.0 (71.6)	85.3 (67.6)	87.1 (69.0)
Erode	80.6 (64.0)	90.3 (71.9)	83 (65.7)	84.6 (67.2)
Salem	60.3 (51.0)	64.0 (53.1)	65.6 (54.1)	63.3 (52.8)
Chinglepet	65.6 (54.0)	69.7 (56.6)	73.6 (59.1)	69.7 (56.6)
Trichy	62.7 (65.0)	72.0 (58.1)	69.3 (69.8)	68.0 (55.6)
Mean	76.5 (61.3)	83.3 (66.6)	80.6 (64.4)	

	L	T	L x T
SEd	3.99	1.99	6.92
CD (P=0.05)	7.96	3.98	13.79

ii. Root length

The longest root was observed in GA₃ 100 ppm (13.7 cm) infused seeds compared to kinetin 100 ppm and control. Irrespective of treatments, the root was the longest in seeds from Coimbatore (14.6 cm) which was on par with Arupukottai (14.1 cm). While it was the shortest in seeds from Trichy (10.2 cm). The interaction between treatment and seed lots indicated that Tirunelveli seed which received kinetin 100 ppm observed the longest root (17.6 cm) (Table 18).

iii. Shoot length

The longest shoot was observed in Erode (13.1 cm) which was followed by Coimbatore and Chinglepet (12.8 and 12.7 cm, respectively). While Anamalai WLS measured the shortest shoot of 9.9 cm. The treatment \times seed lot interaction showed that Erode seeds with GA₃ 100 ppm registered the longest shoot of 16.9 cm (Table 19).

iv. Vigour index

The vigour index was more in GA₃ 100 ppm infused seeds (2247) compared to control (1747). GA₃ 100 ppm infusion recorded 22.3 per cent increase in vigour index over control, while it was only 12.0 per cent increase in kinetin 100 ppm. Among the seed lots, Coimbatore recorded more vigour index (2325) which was followed by Arupukottai (2246) and Tirunelveli (2177). The lowest vigour index was recorded by Trichy (1450). The interaction effect revealed that Coimbatore at GA₃ 100 ppm (2709) recorded more vigour index (Table 20).

v. Drymatter production

The drymatter production was more in GA₃ 100 ppm infused seeds (0.903 g seedling⁻⁵) compared to control (0.580 g seedling⁻⁵). GA₃ 100 ppm infusion recorded 36 per cent increase in drymatter production over control, while it was only

Table 18. Effect of seed infusion with growth regulators on the root length (cm) of *A. lebbek*

Seed lot (L)	Treatments (T)			Mean
	Control	GA ₃	Kinetin	
Tirunelveli	11.1	13.3	17.6	14.0
Ramanathapuram	13.0	15.5	13.6	14.0
Madurai	11.9	14.6	15.3	14.0
Arupukottai	12.3	16.3	13.6	14.1
Anamalai WLS	11.1	14.3	13.0	12.8
Aliyar	13.4	10.9	14.6	13.0
Coimbatore	13.3	17.5	12.9	14.6
Mettupalayam	11.0	13.5	12.3	12.3
Erode	10.8	12.9	12.1	12.0
Salem	12.1	12.4	13.8	12.8
Chinglepet	12.6	12.4	13.1	12.7
Trichy	8.5	10.5	11.6	10.2
Mean	11.8	13.7	13.6	

	L	T	L x T
SEd	0.56	0.28	0.98
CD (P=0.05)	1.12	0.56	1.94

Table 19. Effect of seed infusion with growth regulators on the shoot length (cm) of *A. lebbek*

Seed lot (L.)	Treatments (T)			Mean
	Control	GA ₃	Kinetin	
Tirunelveli	11.6	13.5	9.5	11.5
Ramanathapuram	10.0	12.6	10.8	11.4
Madurai	10.7	13.4	11.8	11.9
Arupukottai	12.0	12.6	10.6	11.8
Anamalai WLS	8.6	10.4	10.6	9.9
Aliyar	10.4	12.7	11.4	11.5
Coimbatore	13.1	13.9	11.5	12.8
Mettupalayam	11.9	12.3	11.7	12.0
Erode	11.9	16.9	10.5	13.1
Salem	11.2	12.8	11.2	11.7
Chinglepet	11.9	14.6	11.5	12.7
Trichy	8.8	12.3	11.8	10.9
Mean	11.0	13.2	11.1	

	L	T	L x T
SEd	0.53	0.27	0.92
CD (P=0.05)	1.05	0.53	1.82

Table 20. Effect of seed infusion with growth regulators on vigour index of *A. lebbek*

Seed lot (L)	Treatments (T)			Mean
	Control	GA ₃	Kinetin	
Tirunelveli	1716	2508	2309	2177
Ramanathapuram	1886	2352	2147	2128
Madurai	1808	2380	1534	1907
Arupukottai	1977	2535	2226	2246
Anamalai WLS	1576	2174	2148	1966
Aliyar	2006	2155	2314	2158
Coimbatore	2104	2709	2162	2325
Mettupalayam	1969	2322	2047	2112
Erode	1830	2691	1876	2132
Salem	1405	1613	1640	1553
Chinglepet	1607	1882	1811	1767
Trichy	1085	1642	1622	1450
Mean	1747	2247	1986	

	L	T	L x T
SEd	28.1	14.1	48.7
CD (P=0.05)	56.0	28.0	97.1

17.0 per cent increase in kinetin 100 ppm. Among the seed lots, Coimbatore recorded more drymatter (0.972 g seedling⁻⁵) which was followed by Chinglepet (0.917 g seedling⁻⁵) and Madurai (0.879 g seedling⁻⁵). The lowest drymatter was recorded by Trichy (0.456 g seedling⁻⁵). The interaction effect revealed that Arupukottai at GA₃ 100 ppm (1.202 g seedling⁻⁵) recorded more drymatter (Table 21)

4.3.4.2. Standardization of a suitable medium for germination

i. Germination

Higher germination was observed in sand medium (77.1 per cent) which was followed by roll towel (74.9 per cent). Top of paper recorded the minimum value of 72.1 per cent. Among the seed lots, Coimbatore (86.9 per cent) recorded more germination which was followed by Aliyar (82.3 per cent). While germination was less in Trichy (65.0 per cent). The interaction effect revealed that Coimbatore seed lot in sand medium (92.0 per cent) followed by Aliyar (89.0 per cent) recorded more germination (Table 22).

ii. Root length

The seedlings from roll towel method showed lengthier root of 12.9 cm. While those from sand medium showed shorter root (11.8 cm). Among seed lots, Coimbatore registered longer root (15.2 cm), while it was shorter in Trichy (11.0 cm). The interaction between seed lot and germination medium showed that under roll towel medium, Coimbatore recorded longer root of 16.0 cm. While shorter root was recorded from Anamalai WLS (9.9 cm) in sand medium (Table 23).

iii. Shoot length

The longer shoot of 12.2 cm was measured in sand medium while it was shorter in roll towel (11.1 cm). Among the seed lots, Coimbatore (13.7 cm) recorded the longest

Table 21. Effect of seed infusion with growth regulators on drymatter production (g seedlings⁻⁵) of *A. lebbek*

Seed lot (L.)	Treatments (T)			Mean
	Control	GA ₃	Kinetin	
Tirunelveli	0.392	0.783	0.652	0.609
Ramanathapuram	0.672	0.932	0.833	0.812
Madurai	0.721	1.052	0.865	0.879
Arupukottai	0.531	1.202	0.805	0.846
Anamalai WLS	0.586	0.711	0.569	0.622
Aliyar	0.476	0.613	0.569	0.582
Coimbatore	0.786	1.166	0.964	0.972
Mettupalayam	0.672	0.905	0.744	0.774
Erode	0.405	0.970	0.572	0.649
Salem	0.537	0.855	0.547	0.646
Chinglepet	0.794	1.070	0.888	0.917
Trichy	0.389	0.577	0.401	0.456
Mean	0.580	0.903	0.701	

	L	T	L x T
SEd	0.0068	0.0034	0.0117
CD (P=0.05)	0.0134	0.0067	0.0232

Table 22. Standardization of a suitable medium for germination - Germination (%)

Seed lot (L)	Germination media (M)				Mean
	Sand	Soil	Top of paper	Roll towel	
Tirunelveli	78.7 (62.5)	77.0 (61.4)	74.0 (59.4)	85.3 (67.5)	78.8 (62.7)
Ramanathapuram	81.7 (64.7)	79.0 (62.7)	78.3 (62.3)	73.7 (59.1)	78.2 (62.2)
Madurai	76.6 (61.1)	71.3 (57.6)	71.7 (57.8)	76.3 (60.9)	74.0 (59.4)
Arupukottai	68.3 (55.8)	69.0 (56.2)	68.7 (56.0)	72.3 (58.3)	69.6 (56.5)
Anamalai WLS	72.3 (58.3)	69.0 (56.2)	81.3 (64.4)	81.3 (64.4)	76.0 (60.8)
Aliyar	89.0 (70.7)	87.3 (69.7)	76.7 (61.1)	77.7 (61.8)	82.3 (65.8)
Coimbatore	92.0 (73.6)	85.7 (67.8)	88.0 (69.7)	82.0 (64.9)	86.9 (69.0)
Mettupalayam	81.7 (64.7)	81.7 (64.7)	73.7 (59.1)	77.3 (61.6)	78.6 (62.5)
Erode	76.3 (60.9)	71.7 (57.8)	66.7 (54.7)	69.0 (56.2)	70.9 (57.4)
Salem	72.7 (58.5)	66.0 (54.3)	64.3 (53.3)	65.3 (53.9)	67.1 (55.0)
Chinglepet	69.3 (56.4)	68.3 (55.8)	60.7 (51.2)	66.6 (54.7)	66.3 (54.5)
Trichy	66.0 (54.3)	60.7 (51.2)	61.3 (51.6)	72.0 (58.1)	65.0 (53.8)
Mean	77.1 (61.8)	73.9 (59.6)	72.1 (58.4)	74.9 (60.1)	-

	L	M	L x M
SEd	0.59	0.34	1.17
CD (P=0.05)	1.16	0.67	2.33

(Figures in parentheses indicate arc sine transformed values)

Table 23. Standardization of a suitable medium for germination – Root length (cm)

Seed lot (L)	Germination media (M)			Mean
	Sand	Soil	Roll towel	
Tirunelveli	12.1	11.9	11.0	11.7
Ramanathapuram	11.8	13.2	14.0	13.0
Madurai	12.8	10.6	10.9	11.5
Arupukottai	10.6	12.7	10.5	11.3
Anamalai WLS	9.9	14.0	12.8	12.2
Aliyar	13.3	13.5	13.3	13.4
Coimbatore	15.2	14.3	16.0	15.2
Mettupalayam	11.7	11.8	14.8	12.7
Erode	11.5	12.5	13.1	12.4
Salem	10.5	11.0	14.0	11.8
Chinglepet	12.0	12.9	12.3	12.4
Trichy	10.4	11.0	11.6	11.0
Mean	11.8	12.5	12.9	

	L	M	L x M
SEd	0.27	0.13	0.47
CD (P=0.05)	0.54	0.27	0.94

shoot. While Salem and Erode (10.5 cm each) which was on par with Madurai (10.8 cm) and Trichy (10.9 cm) recorded the shortest shoot. The interaction between medium and seed lot showed that Coimbatore seed (14.9 cm) in soil medium recorded the longest shoot. Whereas Tirunelveli and Madurai seeds in roll towel medium measured the shortest shoot of 9.9 cm (Table 24).

iv. Vigour index

Higher vigour index (1836) was recorded in sand medium. While roll towel recorded lower value (1736). Among the seed lots, seeds collected from Coimbatore recorded higher value of 2556. Whereas lower value was observed in Trichy (1371). The medium x seed lot interaction revealed that Coimbatore seed lot in sand medium (2744) recorded higher vigour index. While Trichy (1336) recorded lower vigour index in soil medium (Table 25).

v. Drymatter production

More drymatter of seedling was registered by sand medium (0.364 g seedling⁻⁵) and less by soil medium (0.324 g seedling⁻⁵). Among the seed lots, Coimbatore recorded more drymatter (0.406 g seedling⁻⁵). While less drymatter was recorded in Anamalai WLS (0.273 g seedling⁻⁵) and it was on par with Chinglepet (0.285 g seedling⁻⁵). The medium x seed lot interaction revealed that Coimbatore seed in sand medium (0.461 g seedling⁻⁵) recorded higher drymatter production and Anamalai WLS seed in soil medium (0.226 g seedling⁻⁵) recorded lower value (Table 26).

4.3.5. Standardization of quick viability (Tetrazolium) test

1. Preconditioning method

Two methods of preconditioning were employed to break the hard seed and facilitate preparation of seeds for tetrazolium testing. Of the two methods, when seeds

Table 24. Standardization of a suitable medium for germination – Shoot length (cm)

Seed lot (L)	Germination media (M)			Mean
	Sand	Soil	Roll towel	
Tirunelveli	12.5	10.9	9.9	11.1
Ramanathapuram	14.4	12.1	11.0	12.5
Madurai	11.4	11.1	9.9	10.8
Arupukottai	13.3	13.1	11.5	12.6
Anamalai WLS	12.4	11.6	12.4	12.1
Aliyar	11.5	12.9	11.0	11.8
Coimbatore	14.7	14.9	11.5	13.7
Mettupalayam	12.8	12.5	12.0	12.4
Erode	10.6	10.6	10.3	10.5
Salem	10.7	10.1	10.7	10.5
Chinglepet	11.4	11.6	12.1	11.7
Trichy	10.6	11.0	11.0	10.9
Mean	12.2	11.9	11.1	-

	L	M	L x M
SEd	0.25	0.13	0.44
CD (P=0.05)	0.51	0.25	0.88

Table 25. Standardization of a suitable medium for germination - Vigour index

Seed lot (L)	Germination media (M)			Mean
	Sand	Soil	Roll towel	
Tirunelveli	1938	1758	1544	1747
Ramanathapuram	2127	1996	1961	2028
Madurai	1851	1550	1491	1631
Arupukottai	1630	1781	1510	1640
Anamalai WLS	1613	1762	2052	1809
Aliyar	2059	2132	1865	2019
Coimbatore	2744	2502	2423	2556
Mettupalayam	1994	2029	1972	1998
Erode	1692	1655	1562	1636
Salem	1497	1393	1589	1493
Chinglepet	1498	1678	1483	1553
Trichy	1391	1336	1386	1371
Mean	1836	1798	1736	-

	L	M	L x M
SEd	27.2	13.6	47.2
CD (P=0.05)	54.3	27.1	94.0

Table 26. Standardization of a suitable medium for germination - Drymatter production (g seedlings⁻⁵)

Seed lot (L)	Germination media (M)			Mean
	Sand	Soil	Roll towel	
Tirunelveli	0.380	0.306	0.289	0.325
Ramanathapuram	0.401	0.420	0.376	0.399
Madurai	0.367	0.385	0.357	0.369
Arupukottai	0.379	0.310	0.334	0.341
Anamalai WLS	0.306	0.226	0.286	0.273
Aliyar	0.421	0.315	0.331	0.356
Coimbatore	0.461	0.364	0.392	0.406
Mettupalayam	0.404	0.384	0.360	0.383
Erode	0.343	0.313	0.303	0.320
Salem	0.316	0.285	0.280	0.294
Chinglepet	0.286	0.277	0.292	0.285
Trichy	0.302	0.306	0.309	0.306
Mean	0.364	0.324	0.326	-

	L	M	L x M
SEd	0.0023	0.0013	0.0045
CD (P=0.05)	0.0052	0.0026	0.0090

were acid scarified and soaked in water for 12 h, few seeds still remained hard. Whereas, nipping off the seed coat and water soaking resulted in complete imbibition of all seeds. Therefore, the latter was adopted as the preconditioning method.

2. Preparation method

Of the four methods tried, removal of seed coat and splitting of cotyledons into two halves facilitated easy interpretation of staining pattern in seeds compared to other methods viz., longitudinal cut and transverse cut.

3. Tetrazolium concentration

Compared to 0.5%, 1.0% showed better results. Stained seeds were classified as viable and nonviable seeds based on their staining pattern.

Among the seed lots, Mettupalayam recorded the highest percentage of viable seeds (92.3 per cent) and low percentage of non-viable seeds. Anamalai WLS (89.8 per cent). Arupukottai (87.2 per cent) Tirunelveli (86.0 per cent) and Coimbatore (85.3 per cent) followed it. Low percentage of viable seeds was observed in Chinglepet (76.5 per cent) which was on par with Salem (78.0 per cent) (Table 27 and 28).

4.3.6. Standardization of vigour tests

4.3.6.1. NaCl salt stress test

i. Germination

Germination was inversely related to the salt concentration. Compared to germination recorded in tap water irrigation (69.0 per cent), a reduction of 15, 29, 42 and 52 per cent was recorded for 0.25, 0.50, 0.75 and 1.00 % salt concentrations, respectively. Among the seed lots, Tirunelveli (60.1 per cent) showed the highest germination, while Trichy (38.1 per cent) registered the lowest germination. Interaction between seed lot x salt concentration showed that at 0.25% concentration more germination

Table 27. Standardization of quick viability test (Tetrazolium test) in *A. lebbek* - Viable seed (%)

Seed lot (L)	Tetrazolium concentration (C)		Mean
	0.5%	1.0%	
Tirunelveli	88.3 (70.0)	84.0 (66.5)	86.0 (68.3)
Ramanathapuram	82.0 (64.9)	76.7 (61.1)	79.3 (63.0)
Madurai	84.3 (66.7)	80.7 (63.9)	82.5 (65.3)
Arupukottai	79.0 (62.7)	83.3 (65.9)	87.2 (64.3)
Anamalai WLS	88.0 (65.7)	91.7 (73.3)	89.8 (71.5)
Aliyar	79.3 (62.9)	83.7 (66.2)	81.5 (64.6)
Coimbatore	83.0 (65.7)	87.7 (69.5)	85.3 (67.6)
Mettupalayam	90.0 (71.6)	94.7 (76.7)	92.3 (74.1)
Erode	83.7 (66.2)	79.3 (63.0)	81.5 (64.6)
Salem	74.0 (59.4)	82.0 (65.0)	78.0 (62.1)
Chinglepet	78.3 (62.3)	74.7 (60.0)	76.5 (61.0)
Trichy	77.3 (61.6)	80.3 (63.7)	78.8 (62.7)
Mean	82.3 (65.3)	83.2 (66.2)	

	L	C	L x C
SEd	0.78	0.32	1.10
CD (P=0.05)	1.57	0.64	2.22

(Figures in parentheses indicate arc sine transformed values)

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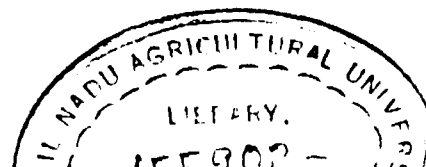


Table 28. Standardization of quick viability test (Tetrazolium test) in *A. lebbek* - Non-viable seed (%)

Seed lot (L)	Tetrazolium concentration (C)		Mean
	0.5%	1.0%	
Tirunelveli	11.7 (20.0)	16.0 (23.5)	13.8 (21.7)
Ramanathapuram	18.0 (25.1)	23.3 (28.9)	20.7 (26.9)
Madurai	15.7 (23.3)	19.3 (26.1)	17.5 (24.7)
Arupukottai	21.0 (20.2)	16.7 (24.1)	18.8 (25.7)
Anamalai WLS	12.0 (20.2)	8.3 (16.7)	10.2 (18.5)
Aliyar	20.7 (27.0)	16.3 (23.8)	18.5 (25.4)
Coimbatore	17.0 (24.3)	12.3 (20.5)	14.7 (22.4)
Mettupalayam	10.0 (18.4)	5.3 (13.3)	7.7 (15.9)
Erode	16.3 (23.8)	20.7 (27.0)	18.5 (25.4)
Salem	26.0 (30.6)	18.0 (25.1)	22.0 (27.9)
Chinglepet	21.7 (27.7)	25.0 (30.0)	23.3 (28.9)
Trichy	22.7 (28.4)	19.7 (26.3)	21.2 (27.4)
Mean	17.7 (24.7)	16.8 (23.8)	

	L	C	L x C
SEd	0.78	0.32	1.10
CD (P=0.05)	1.58	0.64	2.20

(Figures in parentheses indicate arc sine transformed values)

(69.0 per cent) was obtained by Tirunelveli. Whereas it was less in Trichy at 1.0% salt concentration (23.5 per cent) (Table 29).

ii. Root length

Root length showed significant variation among seed lot and salt concentration. Root length recorded from tap water irrigation was 11.26 cm as against 10.74, 9.15, 7.48 and 6.69 cm in 0.25, 0.5, 0.75 and 1.0% salt concentrations respectively. Among seed lots, Tirunelveli (10.78 cm) registered longer root, while Chinglepet (8.37 cm) measured shorter root. The interaction between salt stress and seed lot was significant in respect to root length. Longer root length (12.43 cm) was measured at 0.25% salt concentration by Tirunelveli. Chinglepet recorded the shortest root of 6.25 cm at 1.0% NaCl concentration (Table 30).

iii. Shoot length

As the concentration of the salt solution increases from 0.25 to 1.0 %, the shoot length decreased from 7.28 cm to 4.93 cm. The shoot length in tap irrigation was 7.90 cm. Among seed lots, Tirunelveli recorded the longest shoot of 7.53 cm while Chinglepet and Trichy exhibited the shortest shoot (5.55 cm). The interaction effect indicated that Tirunelveli at 0.25 % salt concentration performed better (8.35 cm) than Chinglepet (4.23 cm) at 1.0% NaCl concentration (Table 31).

iv. Vigour index

Vigour index decreased from 1046 to 392 as the concentration of NaCl increases from 0.25 to 1.0 %. Vigour index of 1340 was registered by irrigating with tap water. Tirunelveli (1147) showed greater vigour index, while Trichy showed lower vigour index (564). The interaction between seed lot and concentration revealed that at

Table 29. Standardization of vigour test in *A. lebbek*- NaCl salt stress test - Germination (%)

Seed lot (L)	Control	NaCl concentrations (C)				Mean
		0.25 %	0.5 %	0.75 %	1.0 %	
Tirunelveli	85.0 (67.2)	69.0 (56.2)	59.0 (50.2)	49.0 (44.4)	38.5 (38.3)	60.1 (51.3)
Ramanathapuram	73.0 (58.7)	62.0 (51.9)	57.0 (45.6)	43.5 (41.2)	35.5 (36.6)	53.0 (46.8)
Madurai	82.5 (65.3)	67.0 (54.9)	57.5 (49.3)	46.0 (42.7)	35.0 (36.3)	57.6 (49.7)
Aliyar	74.0 (59.4)	61.0 (51.4)	50.0 (45.0)	42.0 (40.4)	39.5 (38.9)	53.3 (47.1)
Coimbatore	70.0 (56.8)	62.5 (52.2)	52.0 (46.1)	45.0 (42.1)	38.0 (38.0)	53.5 (47.0)
Erode	64.5 (53.4)	59.0 (50.2)	49.0 (44.4)	38.5 (38.3)	33.5 (35.4)	48.9 (44.4)
Salem	62.0 (57.9)	51.0 (45.6)	43.0 (40.9)	35.0 (36.3)	30.5 (33.5)	44.3 (41.6)
Chinglepet	56.0 (48.4)	48.5 (44.1)	40.5 (39.5)	31.0 (33.8)	25.0 (29.9)	40.2 (39.2)
Trichy	54.0 (47.3)	46.5 (42.9)	38.0 (38.1)	28.5 (32.3)	23.5 (28.9)	38.1 (37.9)
Mean	69.0 (56.5)	58.5 (49.9)	48.9 (44.3)	39.8 (39.1)	33.2 (35.1)	

	L	C	L x C
SEd	0.03	0.22	0.67
CD (P=0.05)	0.60	0.45	1.34

(Figures in parentheses indicate arc sine transformed values)

Table 30 Standardization of vigour test in *A. lebbek* -NaCl salt stress test -Root length (cm)

Seed lot (L.)	Control	NaCl concentrations (C)				Mean
		0.25 %	0.5 %	0.75 %	1.0 %	
Tirunelveli	13.30	12.43	10.20	9.40	8.55	10.78
Ramanathapuram	11.73	10.90	8.65	7.60	6.68	9.11
Madurai	12.40	11.75	9.90	7.50	6.63	9.64
Aliyar	11.40	10.75	9.38	7.40	6.68	9.12
Coimbatore	10.95	10.40	9.63	7.35	6.53	8.97
Erode	10.38	10.35	8.70	7.15	6.28	8.577
Salem	10.35	10.30	8.68	7.13	6.33	8.56
Chinglepet	10.33	9.80	8.60	6.88	6.25	8.37
Trichy	10.48	9.95	8.63	7.00	6.28	8.47
Mean	11.26	10.74	9.15	7.48	6.69	

	L	C	L x C
SEd	0.054	0.039	0.119
CD (P=0.05)	0.106	0.079	0.237

Table 31. Standardization of vigour test in *A. lebbek* -NaCl salt stress test -Shoot length (cm)

Seed lot (L)	Control	NaCl concentrations (C)				Mean
		0.25 %	0.5 %	0.75 %	1.0 %	
Tirunelveli	9.10	8.35	7.68	6.73	5.80	7.53
Ramanathapuram	8.70	8.08	7.58	6.53	5.60	7.30
Madurai	8.30	7.75	6.95	6.08	5.20	6.86
Aliyar	8.58	7.95	7.05	6.18	5.30	7.01
Coimbatore	7.75	7.13	6.20	5.33	4.85	6.25
Erode	7.40	6.95	6.00	5.10	4.60	6.01
Salem	7.10	6.55	5.60	4.80	4.45	5.70
Chinglepet	7.07	6.45	5.45	4.53	4.23	5.55
Trichy	7.12	6.33	5.45	4.50	4.35	5.55
Mean	7.90	7.28	6.44	5.53	4.93	

	L	C	L x C
SEd	0.033	0.024	0.073
CD (P=0.05)	0.065	0.048	0.145

0.25% concentration Tirunelveli (1434) gave higher vigour index which was followed by Madurai at same NaCl concentration (1306) (Table 32).

v. Drymatter production

Compared to drymatter production in tap water irrigation ($0.393 \text{ g seedling}^{-5}$), a reduction of 7, 18, 33 and 39 per cent was recorded in 0.25, 0.50, 0.75 and 1.0% salt concentrations, respectively. Under high stress conditions of 1.0%, Tirunelveli recorded more drymatter $0.256 \text{ g seedling}^{-5}$ which was followed by Madurai ($0.252 \text{ g seedling}^{-5}$). Irrespective of salt concentrations, Madurai ($0.363 \text{ g seedling}^{-5}$) showed more drymatter. The Chinglepet seed lot was less tolerant to the salt stress by showing minimum total drymatter ($0.295 \text{ g seedling}^{-5}$). The interaction effect showed that at 0.25%, Tirunelveli registered more drymatter production ($0.406 \text{ g seedling}^{-5}$) (Table 33).

4.3.6.2. pH test

i. Germination

Significant differences were observed in germination due to irrigation with different pH solutions. As the pH range proceeds towards neutral, there was an increase in the germination. Seeds which were irrigated with solutions of pH 7, 8 and 9 performed better (54.7, 61.7 and 59.7 per cent respectively) when compared to lower pH values. The highest germination was recorded in pH 8 (61.7 per cent) while watering with solutions of pH 10 gave 50.5 per cent. Interaction effect revealed that seeds from Coimbatore irrigated with solutions of pH 8 recorded higher germination of 74.3 per cent, whereas Chinglepet registered lower germination of 14.3 per cent, irrigated with solution of pH 4 (Table 34).

ii. Root length

Root length varied significantly for seed lot and pH solution. The root length was more under pH 9 (15.08 cm) which was followed by pH 8 (14.54 cm). Among seed lots,

Table 32. Standardization of vigour test in *A. lebbek* NaCl salt stress test - Vigour index

Seed lot (L.)	Control	NaCl concentrations (C)				Mean
		0.25 %	0.5 %	0.75 %	1.0 %	
Tirunelveli	1904	1434	1054	790	553	1147
Ramanathapuram	1491	1167	828	615	451	910
Madurai	1708	1306	969	629	414	1005
Aliyar	1497	1141	821	572	473	901
Coimbatore	1304	1095	807	570	433	842
Erode	1146	871	720	473	365	751
Salem	1081	859	614	418	329	660
Chinglepet	974	788	569	354	262	589
Trichy	950	757	535	328	250	564
Mean	1340	1046	769	528	392	

	L	C	L x C
SEd	16.2	12.1	36.2
CD (P=0.05)	32.0	23.9	71.6

Table 33. Standardization of vigour test in *A. lebbek*- NaCl salt stress test - Drymatter production (g seedlings⁻⁵)

Seed lot (L)	Control	NaCl concentrations (C)				Mean
		0.25 %	0.5 %	0.75 %	1.0 %	
Tirunelveli	0.444	0.406	0.349	0.300	0.256	0.350
Ramanathapuram	0.431	0.399	0.344	0.288	0.248	0.342
Madurai	0.429	0.402	0.446	0.288	0.252	0.363
Aliyar	0.384	0.365	0.264	0.250	0.232	0.299
Coimbatore	0.379	0.348	0.281	0.260	0.243	0.302
Erode	0.369	0.345	0.289	0.252	0.232	0.298
Salem	0.371	0.350	0.293	0.256	0.237	0.301
Chinglepet	0.368	0.340	0.281	0.251	0.235	0.295
Trichy	0.364	0.331	0.339	0.239	0.227	0.299
Mean	0.393	0.365	0.321	0.264	0.240	

	L	C	L x C
SEd	0.0028	0.0021	0.0063
CD (P=0.05)	0.0056	0.0042	0.0125

Table 34. Standardization of vigour test in *A. lebbek* - pH test - Germination (%)

Seed lot (L)	Control	pH value (P)							Mean
		4	5	6	7	8	9	10	
runelveli	72.3 (58.2)	20.7 (27.0)	26.3 (30.9)	32.7 (34.9)	49.0 (44.4)	51.7 (45.9)	61.7 (51.8)	56.7 (48.8)	46.4 (42.8)
liyar	69.3 (56.3)	27.3 (31.5)	34.0 (35.7)	38.0 (38.1)	60.3 (50.9)	63.0 (52.5)	56.7 (48.8)	37.3 (37.7)	48.3 (43.9)
ombatore	80.6 (63.9)	33.7 (33.5)	39.0 (38.6)	44.7 (41.9)	58.3 (49.8)	74.3 (59.6)	68.3 (55.8)	60.0 (50.8)	57.4 (49.5)
singlepet	85.3 (67.5)	14.3 (22.2)	23.7 (29.1)	40.7 (39.6)	50.3 (45.2)	57.0 (49.2)	59.3 (50.4)	51.7 (45.9)	47.8 (43.6)
ichy	64.6 (53.5)	20.0 (26.6)	28.3 (32.2)	33.7 (35.5)	55.7 (48.3)	62.3 (52.1)	52.7 (46.5)	46.7 (43.1)	45.5 (42.2)
mean	74.5 (59.9)	23.2 (28.6)	30.3 (33.3)	37.9 (37.9)	54.7 (47.7)	61.7 (51.8)	59.7 (50.7)	50.5 (45.3)	

	L	P	L x P
SEd	0.29	0.37	0.82
CD (P=0.05)	0.58	0.73	1.64

(Figures in parentheses indicate arc sine transformed values)

Aliyar performed better for root length (13.60 cm) compared to other lots. The interaction between seed lot and pH value revealed that at pH 9, Aliyar (16.50 cm) measured the longer root, whereas shorter root was measured with Chinglepet (7.67 cm) at pH 4 (Table 35).

iii. Shoot length

Shoot length varied significantly for the seed lot and pH value. The shoot length was more under pH 9 (14.08 cm) and pH 8 (12.39 cm). Whereas pH 4 recorded shorter shoot of 6.52 cm. Among the seed lots, Aliyar (12.07 cm) recorded longer shoot, whereas Trichy recorded shorter shoot of 9.52 cm. The interaction between seed lot and pH indicated that at pH 9 Tirunelveli registered longer shoot (16.40 cm) and it was on par with Aliyar (16.07 cm). Whereas Chinglepet registered shorter shoot of 5.93 cm when irrigated with pH 4 (Table 36).

iv. Vigour index

There was a gradual increase in the vigour index upto pH 9 (1742) compared to lower pH levels and thereafter vigour index showed a reduction. Considering seed lot alone, Chinglepet registered more vigour index (1378) when compared to Trichy which recorded lower vigour index (1056). Interaction between seed lot and pH level indicated that at pH 9 Coimbatore recorded greater vigour (2002) than Trichy (1432). Whereas Chinglepet at pH 4 registered lower value (194) (Table 37).

v. Drymatter production

Drymatter production varied significantly among pH level and seed lot. With regard to pH levels, drymatter production was more at pH 8 (0.263 g seedling⁻⁵) and less at pH 4 (0.130 g seedling⁻⁵). Among seed lots, Tirunelveli (0.228 g seedling⁻⁵) recorded more drymatter than Trichy (0.169 g seedling⁻⁵). Seed lot x pH value interaction revealed

Table 35 Standardization of vigour test in *A. lebbek* - pH test - Root length (cm)

Seed lot (L)	Control	pH value (P)							Mean
		4	5	6	7	8	9	10	
Gunelveli	15.06	10.70	11.20	10.60	11.10	13.53	12.80	13.23	12.28
Yiyar	11.60	10.70	11.70	13.50	15.93	14.10	16.50	14.80	13.60
Simbatore	13.06	9.67	9.90	11.53	13.50	14.13	15.60	10.83	12.28
Singlepet	14.50	7.67	9.13	10.10	14.77	16.33	15.00	10.67	12.27
Ichy	13.80	9.90	10.23	11.87	13.47	14.60	15.50	11.20	12.57
Mean	13.61	9.73	10.43	11.52	13.75	14.54	15.08	12.15	

	L	P	L x P
SEd	0.156	0.197	0.441
CD (P=0.05)	0.310	0.393	0.879

Table 36. Standardization of vigour test in *A. lebbek* - pH test - Shoot length (cm)

Seed lot (L)	Control	pH value (P)							Mean
		4	5	6	7	8	9	10	
Tirunelveli	14.60	5.90	9.23	10.17	11.67	13.43	16.40	12.27	11.71
Aliyar	11.43	7.37	9.57	12.47	14.53	13.97	16.07	11.17	12.07
Coimbatore	12.70	6.57	8.20	9.50	10.90	12.07	13.70	10.10	10.47
Chinglepet	11.37	5.93	7.83	8.23	10.23	11.63	12.53	9.23	9.63
Trichy	12.17	6.83	7.47	8.07	9.17	10.83	11.70	9.90	9.52
Mean	12.45	6.52	8.47	9.69	11.30	12.39	14.08	10.53	

	L	P	L x P
SEd	0.143	0.181	0.404
CD (P=0.05)	0.284	0.359	0.804

Table 37. Standardization of vigour test in *A. lebbek* – pH test - Vigour index

Seed lot (L)	Control	pH value (P)							Mean
		4	5	6	7	8	9	10	
Tirunelveli	2146	344	539	679	1115	1393	1801	1445	1183
Aliyar	1597	494	723	987	1835	1768	1885	969	1277
Coimbatore	2079	546	706	939	1423	1949	2002	1257	1362
Chinglepet	2207	194	401	746	1258	1594	1633	1036	1378
Trichy	1679	335	501	671	1259	1585	1432	985	1056
Mean	1942	383	574	804	1378	1056	1742	1138	

	L	P	L x P
SEd	11.6	14.7	32.9
CD (P=0.05)	23.2	29.3	65.6

that at pH 9 more drymatter production was recorded by Coimbatore (0.318 g seedling⁻⁵) and at pH4 Chinglepet recorded less (0.105 g seedling⁻⁵) (Table 38).

4.3.6.3. Poly Ethylene Glycol (PEG) test

i. Germination

Significant variation was noticed for germination among seed lots and PEG concentrations. Higher germination was obtained at 0.75% PEG concentration (82.6 per cent) which was followed by 0.50% PEG concentration (81.3 per cent). But at high concentrations of PEG (1.25 %), the germination was only 71.9 per cent. The control gave 75.4 per cent germination. Among seed lots, Coimbatore performed better for the germination (83.9 per cent) while Aliyar recorded lower germination of 69.8 per cent. The interaction between seed lot and concentration was significant and expressed that at 0.75 % PEG concentration Coimbatore (89.0 per cent) and at 1.25% Aliyar (64.5 per cent) recorded higher and lower values for germination respectively (Table 39).

ii. Root length

Significant variation was noticed among the seed lots and PEG concentrations. PEG at lower concentrations of 0.25 and 0.5% measured longer root of 12.9 cm each, while higher concentrations of 0.75 and 1.0% recorded 12.2 and 11.8 cm, respectively. Seedlings from Coimbatore (13.9 cm) measured longer root, while Aliyar (10.9 cm) measured the shorter root. The interaction showed that Coimbatore at 0.25 % concentration recorded more root length (14.9 cm) while shorter root length was recorded in Aliyar (9.9 cm) at 1.25% PEG concentration (Table 40).

iii. Shoot length

The shoot lengths at 0.5 and 0.75% were 11.8 and 11.9 cm respectively which were on par with each other. Among seed lots, Coimbatore recorded longer shoot

Table 38. Standardization of vigour test in *A. lebbek* - pH test - Drymatter production (g seedlings⁵)

Seed lot (L)	Control	pH value (P)							Mean
		4	5	6	7	8	9	10	
Tirunelveli	0.298	0.148	0.163	0.195	0.231	0.252	0.279	0.254	0.228
Aliyar	0.259	0.159	0.174	0.185	0.211	0.224	0.244	0.235	0.211
Coimbatore	0.314	0.134	0.132	0.173	0.203	0.263	0.318	0.269	0.226
Chinglepet	0.276	0.105	0.123	0.139	0.187	0.227	0.244	0.225	0.191
Trichy	0.210	0.106	0.116	0.129	0.169	0.215	0.208	0.194	0.169
Mean	0.272	0.130	0.142	0.164	0.200	0.263	0.259	0.235	

	L	P	L x P
SEd	0.0015	0.0019	0.0043
CD (P=0.05)	0.0030	0.0038	0.0085

Table 39. Standardization of vigour test in *A. lebbek* - Poly Ethylene Glycol (PEG) test - Germination (%)

Seed lot (L)	Control	PEG concentrations (C)					Mean
		0.25 %	0.50 %	0.75 %	1.0 %	1.25%	
Tirunelveli	75.0 (60.0)	72.5 (58.4)	81.0 (64.2)	84.0 (66.4)	74.0 (59.3)	69.5 (56.5)	76.0 (60.8)
Aliyar	71.0 (57.4)	66.0 (54.3)	71.5 (57.7)	77.5 (61.7)	68.5 (55.9)	64.5 (53.4)	69.8 (56.7)
Coimbatore	84.0 (66.4)	80.5 (63.8)	86.0 (68.0)	89.0 (70.7)	84.0 (66.4)	80.0 (63.4)	83.9 (66.5)
Chinglepet	78.5 (62.4)	83.0 (65.7)	88.5 (70.2)	79.5 (63.1)	73.5 (59.0)	68.5 (55.9)	78.6 (62.7)
Trichy	68.5 (55.9)	73.5 (59.0)	79.5 (63.1)	83.0 (65.7)	82.0 (64.9)	77.0 (61.4)	77.3 (61.7)
Mean	75.4 (60.4)	75.1 (60.2)	81.3 (64.6)	82.6 (65.5)	76.4 (61.1)	71.9 (58.1)	-

	L	C	L x C
SEd	0.47	0.52	1.16
CD (P=0.05)	0.97	1.06	2.37

(Figures in parentheses indicate arc sine transformed values)

Table 40. Standardization of vigour test in *A. lebbek* - Poly Ethylene Glycol (PEG) test - Root length (cm)

Seed lot (L.)	Control	PEG concentrations (C)					Mean
		0.25 %	0.50 %	0.75 %	1.0 %	1.25%	
Tirunelveli	13.3	12.7	13.2	13.0	12.0	12.5	12.8
Aliyar	11.3	11.9	11.4	10.5	10.3	9.9	10.9
Coimbatore	14.4	14.9	14.2	13.8	13.3	13.1	13.9
Chinglepet	12.4	12.1	12.6	11.2	11.0	10.4	11.6
Trichy	13.3	13.2	13.3	12.7	12.3	12.0	12.8
Mean	12.9	12.9	12.9	12.2	11.8	11.6	-

	L	C	L x C
SEd	0.113	0.124	0.277
CD (P=0.05)	0.231	0.253	0.565

(13.9 cm) while shorter shoot was recorded in Aliyar (10.2 cm). The interaction effect expressed that Coimbatore (14.7 cm) and Aliyar (9.7 cm) both at 0.5% PEG concentration recorded the longer and shorter shoot lengths, respectively (Table 41).

iv. Vigour index

Differences among the seed lots, PEG concentrations and their interactions were significant for the vigour index. The vigour index was greater at PEG 0.5% concentration (2021) and it was on par with 0.75% concentration (2002). Among seed lots, Coimbatore (2339) and Aliyar (1470) registered higher and lower values of vigour index, respectively. The interaction between seed lot and PEG concentration showed that Coimbatore at 0.75% PEG concentration registered greater vigour index of 2514, while vigour index was lower in Aliyar 1284 at 1.25% PEG concentration (Table 42).

v. Drymatter production

Seedling drymatter showed significant variations among the concentrations and seed lots. The seedling drymatter was more in 0.5% PEG concentration (0.335 g seedling⁻⁵) followed by 0.25% concentration (0.328 g seedling⁻⁵) which showed 8 and 6.0% increase over control (0.309 g seedling⁻⁵). Among the seed lots, Aliyar recorded higher drymatter production (0.349 g seedling⁻⁵) which was followed by Coimbatore (0.323 g seedling⁻⁵). Whereas Chinglepet recorded a lower value of 0.264 g seedling⁻⁵. The interaction effect showed that Aliyar (0.401 g seedling⁻⁵) at 0.5% PEG concentration and Chinglepet (0.202 g seedling⁻⁵) at 1.25% PEG concentration recorded the higher and lower values of drymatter production, respectively (Table 43).

4.3.6.4. Accelerated aging test

Germination showed significant variation among the seed lot, period of aging and their interactions. Significant variation among seed lot, period of aging and their

Table 41 Standardization of vigour test in *A. lebbek* - Poly Ethylene Glycol (PEG) test - Shoot length (cm)

Seed lot (L)	Control	PEG concentrations (C)					Mean
		0.25 %	0.50 %	0.75 %	1.0 %	1.25%	
Tirunelveli	11.9	10.9	11.8	11.9	11.2	10.3	11.3
Aliyar	10.8	9.9	9.7	10.3	10.4	10.0	10.2
Coimbatore	13.3	13.9	14.7	14.5	13.9	13.6	13.9
Chinglepet	12.4	12.8	12.0	11.0	11.2	11.0	11.7
Trichy	10.5	10.7	11.0	11.9	12.2	11.8	11.3
Mean	11.8	11.6	11.8	11.9	11.7	11.3	-

	L	C	L x C
SEd	0.113	0.123	0.276
CD (P=0.05)	0.230	0.252	0.564

Table 42. Standardization of vigour test in *A. lebbek* - Poly Ethylene Glycol (PEG) test – Vigour index

Seed lot (L)	Control	PEG concentrations (C)					Mean
		0.25 %	0.50 %	0.75 %	1.0 %	1.25%	
Tirunelveli	1887	1708	2017	2088	1713	1585	1833
Aliyar	1566	1436	1505	1612	1418	1284	1470
Coimbatore	2319	2311	2477	2514	2281	2136	2339
Chinglepet	1939	2063	2173	1765	1625	1464	1838
Trichy	1631	1750	1932	2033	2005	1829	1863
Mean	1868	1853	2021	2002	1808	1659	-

	L	C	L x C
SEd	16.7	18.3	40.8
CD (P=0.05)	34.0	37.3	83.4

Table 43. Standardization of vigour test in *A. lebbek* - Poly Ethylene Glycol (PEG) test - Drymatter production (g seedlings⁵)

Seed lot (L)	Control	PEG concentrations (C)					Mean
		0.25 %	0.50 %	0.75 %	1.0 %	1.25%	
Tirunelveli	0.294	0.321	0.307	0.274	0.251	0.216	0.277
Aliyar	0.337	0.387	0.401	0.372	0.316	0.287	0.349
Coimbatore	0.324	0.350	0.361	0.332	0.296	0.278	0.323
Chinglepet	0.307	0.290	0.305	0.260	0.222	0.202	0.264
Trichy	0.287	0.293	0.302	0.284	0.242	0.216	0.270
Mean	0.309	0.328	0.335	0.304	0.265	0.240	-

	L	C	L x C
SEd	0.0018	0.0020	0.0045
CD (P=0.05)	0.0037	0.0041	0.0091

interaction were also observed for all seedling parameters like root length, shoot length, vigour index and drymatter production.

i. Germination

The germination and aging period was inversely related. The germination at the end of aging test was 29.0 per cent against initial value of 82.0 per cent in non-aged seed (0 Days after aging). The germination irrespective of seed lots showed a reduction of 9, 20, 32, 44 and 65 per cent in 2, 4, 6, 8 and 10 days after aging, respectively (Table 44).

ii. Root length

In all the seed lots, the root length showed a steady decline as the period of aging increased. The average root length of 17.4 cm measuring at the initial period decreased to 10.8 cm at the end of aging. This showed a reduction of 38.0 per cent over initial value. Among the seed lots, the root was the longest in seed samples from Mettupalayam (18.7 cm) which was followed by Anamalai WLS and Erode (17.5 and 17.0 cm, respectively). The shortest root was recorded in Madurai (10.5 cm). The interaction effect indicated longest root for non-aged seeds of Mettupalayam (23.6 cm) (Table 45).

iii. Shoot length

As the period of aging increases, there was a steady decrease in the shoot length (8.4 cm at the end of aging) compared to non-aged seed (13.4 cm). Irrespective of seed lots, at 10 days after aging, a reduction of 37 per cent in shoot length was observed. The shoot was the longest in Anamalai WLS (14.9 cm) which was on par with Mettupalayam (14.8 cm). The shortest shoot was recorded in Salem (8.2 cm). Shoot length reduction was more in Trichy (51.6 per cent) (Table 46).

Table 44. Standardization of vigour test in *A. ichhok* – Accelerated aging test – Germination (%)

Seed lot (L)	0 DAA	2 DAA	4 DAA	6 DAA	8 DAA	10 DAA	Mean
Tirunelveli	93.0 (74.12)	88.0 (69.8)	81.0 (63.80)	74.0 (59.35)	61.0 (51.36)	48.0 (43.57)	74.0 (60.30)
Ramanathapuram	89.0 (70.63)	84.0 (66.10)	76.0 (60.33)	71.0 (57.10)	66.0 (54.34)	61.0 (51.36)	74.0 (59.97)
Madurai	86.0 (68.04)	77.0 (61.02)	67.0 (54.95)	59.0 (50.19)	56.0 (48.16)	26.0 (30.64)	62.0 (52.17)
Arupukottai	88.0 (69.73)	79.0 (62.38)	61.0 (51.36)	50.0 (45.00)	31.0 (33.83)	16.0 (23.91)	54.0 (47.76)
Anamalai WLS	90.0 (72.06)	84.0 (66.46)	78.0 (62.04)	69.0 (55.86)	64.0 (52.84)	50.0 (45.00)	72.0 (59.04)
Aliyar	79.0 (72.06)	69.0 (55.88)	60.0 (50.48)	57.0 (45.57)	42.0 (40.39)	17.0 (23.85)	53.0 (46.54)
Coimbatore	83.0 (63.08)	79.0 (62.38)	67.0 (54.64)	58.0 (49.60)	50.0 (44.71)	39.0 (38.64)	62.0 (52.61)
Mettupalayam	93.0 (65.67)	82.0 (64.91)	78.0 (61.69)	67.0 (54.94)	58.0 (49.61)	49.0 (44.43)	71.0 (58.38)
Erode	86.0 (74.70)	80.0 (63.08)	70.0 (56.49)	62.0 (51.95)	55.0 (47.87)	25.0 (29.93)	63.0 (52.96)
Salem	69.0 (68.45)	60.0 (50.36)	53.0 (46.44)	39.0 (38.65)	17.0 (24.27)	6.0 (13.20)	41.0 (38.25)
Chinglepet	66.0 (56.34)	61.0 (57.36)	56.0 (48.45)	43.0 (40.69)	27.0 (31.31)	12.0 (19.82)	44.0 (40.99)
Trichy	61.0 (51.36)	57.0 (48.74)	50.0 (47.72)	32.0 (34.45)	21.0 (26.91)	6.0 (13.44)	38.0 (36.60)
Mean	82.0 (65.69)	74.8 (60.26)	66.0 (54.61)	56.0 (48.61)	46.0 (42.13)	29.0 (31.48)	58.9 (50.47)
SEd	L	A	L x A	DAA- days after aging (A)			
CD (P=0.05)	0.652	0.461	1.597				
	1.300	0.919	3.182				

(Figures in parentheses indicate arc sine transformed values)

Table 45. Standardization of vigour test in *A. lebbek* - Accelerated aging test - Root length (cm)

Seed lot (L)	0 DAA	2 DAA	4 DAA	6 DAA	8 DAA	10 DAA	Mean
Tirunelveli	15.2	14.3	12.6	11.3	11.8	10.4	12.6
Ramanathapuram	14.3	13.3	13.0	10.7	9.7	8.9	11.6
Madurai	13.0	11.8	11.0	10.3	8.9	8.2	10.5
Arupukottai	15.7	15.1	14.1	12.4	10.3	9.8	12.9
Anamalai WLS	22.6	20.0	19.6	16.5	14.3	12.1	17.5
Aliyar	18.0	17.1	16.3	15.2	13.7	12.3	15.4
Coimbatore	19.4	18.1	17.4	16.0	15.0	13.8	16.6
Mettupalayam	23.6	22.1	19.4	17.2	15.5	14.6	18.7
Erode	19.7	18.9	18.0	16.8	15.3	12.8	17.0
Salem	16.4	15.7	14.6	13.3	12.0	9.4	13.5
Chinglepet	14.5	13.5	12.8	11.8	10.4	9.0	11.9
Trichy	17.0	15.8	14.1	12.9	11.1	9.7	13.4
Mean	17.4	16.3	15.2	13.7	12.4	10.8	14.3

DAA-Days after aging (A)

L x A

A

L

SEd

CD (P=0.05)

0.143

0.280

0.101

0.201

0.349

0.700

Table 46. Standardization of vigour test in *A. ichhok* - Accelerated aging test - Shoot length (cm)

Seed lot (L)	0 DAA	2 DAA	4 DAA	6 DAA	8 DAA	10 DAA	Mean
Tirunelveli	11.8	11.1	10.3	9.5	9.0	8.3	10.0
Ramanathapuram	11.0	10.6	9.7	8.9	8.4	8.0	9.4
Madurai	10.5	10.0	9.0	8.9	7.4	6.4	8.7
Arupukottai	14.7	13.7	12.7	11.3	9.9	9.5	11.9
Anamalai WLS	17.2	16.4	15.4	14.4	13.6	12.4	14.9
Aliyar	16.8	15.8	15.0	13.4	10.6	8.7	13.4
Coimbatore	14.6	14.0	13.2	12.6	11.2	9.8	12.6
Mettupalayam	17.7	16.5	15.6	13.9	13.0	12.1	14.8
Erode	13.3	12.9	11.2	10.1	8.7	7.3	10.6
Salem	9.8	10.0	8.7	7.9	7.3	5.7	8.2
Chinglepet	11.9	11.1	10.2	9.0	8.2	7.3	9.6
Trichy	12.2	10.9	10.4	9.2	7.4	5.9	9.3
Mean	13.4	12.7	11.8	10.7	9.5	8.4	11.1

DAA-Days after aging (A)

L x A

A

L

0.124

0.087

0.247

0.304

0.175

0.606

SEd
CD (P=0.05)

iv. Vigour index

The vigour index exhibited a significant and gradual reduction in seeds collected from different seed lots during aging. Compared to the non-aged seeds, loss of vigour at 10 days after aging was less in seeds from Ramanathapuram (54.0 per cent) while higher reduction was noticed in samples from Trichy (95.0 per cent) and Salem (95.0 per cent). Irrespective of seed lots, the reduction at the end of aging period was 76.3 per cent as compared to non-aged seed. After 8 days after aging, there was a drastic reduction in the vigour index (Table 47).

v. Drymatter production

Considering the seed lots alone, Mettupalayam ($0.313 \text{ g seedling}^{-5}$) on par with Arupukottai ($0.302 \text{ g seedling}^{-5}$) registered more drymatter production. The reduction in drymatter production was 25.0, 51.0 and 67.0 per cent at 2, 6, and 10 days after aging respectively compared to non-aged seeds (Table 48).

4.3.7. Standardization of seed health test

1. Blotter medium

Under blotter medium, a total of eight different fungal genera were recorded in the seed lots of *Albizia lebbek* collected from twelve different seed lots. *Aspergillus niger*, *Aspergillus flavus*, *Penicillium* spp., *Alternaria* spp., *Geotrichum* spp., and *Chaetomium* spp., were the most frequently occurring fungal spp., in most of the seed lots. *Aspergillus tenuis* was recorded only in Tirunelveli seeds alone. *Mucor* spp., was found to occur in seeds from Tirunelveli, Anamalai WLS, Coimbatore and Erode. *Geotrichum* spp., was identified in Aliyar and Chinglepet while occurrence of *Curvularia* spp., was confined to Anamalai WLS alone. Among seed lots, seeds collected from Madurai recorded less number of fungal spp., i.e., *Aspergillus flavus* and

Table 47. Standardization of vigour test in *A. lebbek* - Accelerated aging test - Vigour index

Seed lot (L)	0 DAA	2 DAA	4 DAA	6 DAA	8 DAA	10 DAA	Mean
Tirunelveli	2496	2229	1839	1539	1263	886	1709
Ramanathapuram	2248	1991	1714	1375	1195	1025	1591
Madurai	2017	1664	1341	1130	902	379	1239
Arupukottai	2666	2271	1635	1180	626	317	1449
Anamalai WLS	3593	3058	2727	2116	1863	1211	2428
Aliyar	2763	2253	1862	1459	1020	345	1617
Coimbatore	2818	2516	2028	1659	1294	921	1873
Mettupalayam	3841	3165	2708	2084	1650	1307	2459
Erode	2851	2524	2026	1668	1346	504	1820
Salem	1804	1536	1219	825	328	82	966
Chinglepet	1738	1500	1283	883	500	187	1015
Trichy	1781	1508	1208	707	379	85	995
Mean	2551	2185	1799	1385	1031	604	1592
	L	A	L x A				
SEd	27.79	19.65	68.07				
CD (P=0.05)	55.40	39.17	135.71				

Table 48. Standardization of vigour test in *A. lebbek* – Accelerated aging test - Drymatter production (g seedlings⁻⁵)

Seed lot (L)	0 DAA	2 DAA	4 DAA	6 DAA	8 DAA	10 DAA	Mean
Tirunelveli	0.375	0.345	0.250	0.200	0.200	0.145	0.268
Ramanathapuram	0.260	0.240	0.150	0.105	0.105	0.085	0.175
Madurai	0.300	0.290	0.155	0.105	0.105	0.080	0.189
Arupukottai	0.465	0.410	0.280	0.220	0.220	0.105	0.302
Anamalai WLS	0.295	0.285	0.215	0.175	0.175	0.100	0.219
Aliyar	0.360	0.320	0.250	0.200	0.200	0.155	0.263
Coimbatore	0.280	0.250	0.195	0.125	0.125	0.095	0.190
Mettupalayam	0.420	0.395	0.295	0.265	0.265	0.160	0.313
Erode	0.395	0.355	0.225	0.185	0.185	0.120	0.263
Sallem	0.250	0.195	0.095	0.075	0.075	0.060	0.133
Chinglepet	0.290	0.240	0.195	0.125	0.125	0.095	0.192
Trichy	0.295	0.270	0.205	0.190	0.190	0.120	0.220
Mean	0.332	0.249	0.209	0.164	0.164	0.110	0.2
	L	A	L x A	DAA-Days after aging (A)			
SEd	0.006	0.004	0.016				
CD (P=0.05)	0.013	0.009	0.032				

Chaetomium spp. Occurrence of *Aspergillus niger* and *Aspergillus flavus* were abundant in seeds from Salem and Chinglepet (Table 49).

2. Agar medium

A total of six fungi, mostly *Aspergillus* spp., was isolated from seeds of *A. lebbek*. *Aspergillus niger* and *A. flavus* were dominating on the seeds of almost all the twelve seed lots. *Penicillium* spp., occurred only in Coimbatore and Salem seed lots. Seeds of Madurai, Mettupalayam and Salem recorded the presence of *Aspergillus clavatus*. Chinglepet and Trichy recorded only *Aspergillus niger* and *Aspergillus flavus*. Among seed lots, occurrence of fungi was less in Madurai. Seeds from Salem, Chinglepet and Trichy showed higher percentage of fungi infection by *Aspergillus flavus*. Apart from pathogenic fungi, bacterial colonization with *Bacillus subtilis* was also found to be present in seeds from Ramanathapuram, Anamalai WLS and Coimbatore (Table 50).

4.4. STANDARDIZATION OF NURSERY PRACTICES FOR ELITE SEEDLING PRODUCTION

4.4.1. Container size study

1. At one month after sowing

At one month after sowing, the seedlings showed significantly more root length (30.6 cm), shoot length (8.1 cm), shoot collar diameter (0.28 cm), number of leaves (9.0), number of nodules (20.8) and total dry weight (2.278 g seedling⁻⁵) in 15 x 25 cm size polybag. They were less (11.0 cm, 6.5 cm, 0.14 cm, 4.4, 2.6 and 0.745 g seedling⁻⁵, respectively) in seedlings raised in nursery bed (Table 51).

2. At two months after sowing

Seedling growth parameters showed significant variations among the polybags. The root length of 30.6 cm was measured in 15 x 25 cm polybag, while in nursery bed it measured 11.0 cm only. As the size of the polybag increases, the length of the shoot also

Table 49. Seed fungi and their frequency (%) on various seed lots of *A. lebbek* seeds in blotter test

Seed lot	<i>Aspergillus niger</i>	<i>Aspergillus tenuis</i>	<i>Aspergillus flavus</i>	<i>Mucor spp.</i>	<i>Penicillium spp.</i>	<i>Alternaria spp.</i>	<i>Geotrichum spp.</i>	<i>Chaetomium spp.</i>	<i>Curvularia spp.</i>	<i>Fusarium spp.</i>
Tirunelveli	42	5	27	8	-	10	-	-	-	-
Ramanathapuram	9	-	25	-	3	28	-	20	-	-
Madurai	-	-	9	-	-	-	-	18	-	-
Arupukottai	-	-	-	-	-	-	-	-	-	-
Anamalai WLS	17	-	32	9	2	9	-	5	5	-
Aliyar	3	-	18	-	-	13	10	7	-	5
Coimbatore	15	-	15	5	-	-	-	5	-	-
Mettupalayam	5	-	6	-	-	-	-	5	-	-
Erode	28	-	29	4	-	-	-	4	-	-
Salem	64	-	69	-	36	31	-	-	-	21
Chinglepet	33	-	31	-	19	28	5	-	-	11
Trichy	44	-	19	-	-	10	-	-	-	5

Not analysed statistically

Table 50. Seed fungi and their frequency (%) on various seed lots of *A. lebbek* seeds in Agar medium

Seed lot	<i>Aspergillus niger</i>	<i>Aspergillus flavus</i>	<i>Aspergillus fumigatus</i>	<i>Aspergillus clavatus</i>	<i>Penicillium spp</i>	<i>Alternaria spp</i>
Tirunelveli	28	-	-	-	-	4
Ramanathapuram	8	16	-	-	-	-
Madurai	-	4	4	4	-	-
Arupukottai	4	-	-	-	-	-
Anamalai WLS	8	8	4	-	-	-
Aliyar	4	8	-	-	-	-
Coimbatore	12	4	-	-	8	4
Mettupalayam	8	4	8	8	-	-
Erode	16	-	8	-	-	4
Salem	36	20	-	8	24	4
Chinglepet	24	4	-	-	-	-
Trichy	32	4	-	-	-	-

Not analysed statistically

increased. The values were 13.4 cm and 20.0 cm in 10 x 15 cm and 15 x 25 cm polybag respectively. Whereas nursery bed measured only 9.6 cm. The shoot length, shoot collar diameter, number of leaves, number of nodules and total dry weight of the seedlings in 15 x 25 cm polybag showed an increase of 52.0, 58.8, 45.8, 79.7 and 89.1 per cent, respectively over the seedlings grown in nursery bed (Table 52).

3. At five months after sowing

Significant variation was recorded for root length due to polybag size. The root length of seedlings in 15x25 cm polybag showed an increase of 78 per cent over nursery bed raised seedlings. The longest root of 36.0 cm was measured in seedlings from 15 x 25 cm polybag. While seedlings from nursery bed recorded the shortest root of 20.2 cm. The shoot collar diameter (0.49 cm) in 15 x 25 cm polybag size showed 75 per cent increase over the nursery bed (0.28 cm) (Table 53).

The root and shoot dry weights were more in seedlings raised in 15 x 25 cm polybag (2.142 and 1.951 g seedling⁻¹, respectively). Whereas they were low in nursery bed (0.613 and 0.492 g seedling⁻¹, respectively). The total dry weight was more in seedlings raised in 15 x 25 cm polybag (4.093 g seedling⁻¹) followed by 10 x 15 cm polybag. The total dry weight was less in nursery bed (1.105 g seedling⁻¹) (Table 53).

4.4.2. Root trainer study

1. At one month after sowing

The growth parameters of the seedlings raised in root trainers performed significantly better than those raised under nursery beds.

i. Root length

The root of the seedling grown in the root trainer measured longer than the nursery bed. As the capacity of the root trainer increases, the root length was also

Table 51. Effect of container size on seedling growth of *A. lebbek* at one month after sowing

Container size	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of nodules	Root fresh weight (g seedlings ⁻⁵)	Shoot fresh weight (g seedlings ⁻⁵)	Root dry weight (g seedlings ⁻⁵)	Shoot dry weight (g seedlings ⁻⁵)	Total dry weight (g seedlings ⁻⁵)
Nursery bed	11.0	6.5	0.14	4.4	2.6	0.283	1.984	0.145	0.600	0.745
10 x 15 cm Polybag	23.0	7.2	0.23	6.6	17.8	1.622	2.936	0.465	0.927	1.392
15 x 25 cm Polybag	30.6	8.1	0.28	9.0	20.8	1.927	4.759	0.666	1.612	2.278
Mean	21.6	7.3	0.21	6.7	13.7	1.277	3.227	0.425	1.046	1.471
SEd	1.69	0.31	0.023	0.82	3.05	0.007	0.008	0.006	0.004	0.010
CD (P=0.05)	3.69	0.68	0.050	1.80	6.64	0.015	0.017	0.013	0.008	0.021

Table 52. Effect of container size on seedling growth of *A. lebbek* at two months after sowing

Container size	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of nodules	Root fresh weight (g seedlings ⁻⁵)	Shoot fresh weight (g seedlings ⁻⁵)	Root dry weight (g seedlings ⁻⁵)	Shoot dry weight (g seedlings ⁻⁵)	Total dry weight (g seedlings ⁻⁵)
Nursery bed	11.0	9.6	0.14	5.2	5.2	0.309	2.081	0.158	0.615	0.773
10 x 15 cm Polybag	23.0	13.4	0.24	8.2	19.0	9.439	9.585	3.486	3.489	6.975
15 x 25 cm Polybag	30.6	20.0	0.34	9.6	25.6	16.739	19.839	3.549	3.534	7.083
Mean	21.6	14.3	0.23	7.7	16.6	8.828	10.501	2.398	2.546	4.944
SEd	1.69	0.97	0.028	0.79	1.24	0.072	0.031	0.016	0.0194	0.035
CD (P=0.05)	3.69	2.17	0.062	1.72	2.70	0.0156	0.067	0.035	0.042	0.077

Table 53. Effect of container size on seedling growth of *A. lebbek* at five months after sowing

Container size	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Root dry weight (g seedling ⁻¹)	Shoot dry weight (g seedling ⁻¹)	Total dry weight (g seedling ⁻¹)
Nursery bed	20.2	11.2	0.28	0.613	0.492	1.105
10 x 15 cm poly bag	28.5	16.3	0.37	1.089	0.873	1.962
15 x 25 cm poly bag	36.0	23.7	0.49	2.142	1.951	4.093
Mean	28.2	17.1	0.38	1.281	1.105	2.386
SEd	1.55	0.72	0.010	0.029	0.019	0.048
CD (P=0.05)	3.31	1.54	0.021	0.062	0.039	0.101

increased. The root length of seedling raised in 150 cc, 300 cc and 600 cc root trainers were 10.5, 13.8 and 23.4 cm respectively. It was only 10.7 cm in nursery bed (Table 54).

ii. Shoot length

Seedlings raised in root trainers recorded significantly longer shoot compared to the seedlings from nursery bed. Among the root trainers, 600 cc root trainer measured longer shoot of 11.8 cm which accounted for 51 per cent increase over the nursery bed (7.8 cm) (Table 54).

iii. Shoot collar diameter

Seedlings raised in 600 cc capacity root trainer recorded more shoot collar diameter of 0.20 cm, while the nursery bed registered low value of 0.13 cm (Table 54).

iv. Number of leaves

Significant variations were observed for the number of leaves in the seedlings raised under root trainer and nursery bed. The number of leaves in the root trainers was more compared to the nursery bed. The 600 cc root trainer recorded more number of leaves (9.6) whereas it was less in nursery bed (6.2). The respective increases were 23, 29 and 54 per cent in the 150, 300 and 600 cc root trainers over the nursery bed (Table 54).

v. Number of nodules

Non-significant difference was noticed for number of nodules due to root trainers.

vi. Root and shoot fresh weights

Significant variations were observed for root and shoot fresh weights due to root trainers. Compared to the root fresh weight recorded from nursery bed (0.298 g

seedling⁻⁵), there was a twofold increase in 600 cc root trainer (0.879 g seedling⁻⁵) (Table 54).

Shoot fresh weight of the seedlings raised in 600 cc root trainer (3.453 g seedling⁻⁵) recorded an increase of 92 per cent over nursery bed (1.801 g seedling⁻⁵) (Table 54).

vii. Root and shoot dry weights

Root trainers showed significant variations for root and shoot dry weights. The root and shoot dry weights were more in 600 cc root trainer (0.352 and 1.220 g seedling⁻⁵, respectively). This accounted for 84 and 109 per cent increase over the nursery beds (Table 54).

viii. Total dry weight

Significant variation was observed for the total dry weight of the seedlings due to root trainers. The seedlings raised in root trainers recorded more total dry weight than the nursery bed. Among the root trainers, 600 cc capacity registered more total dry weight (1.572 g seedling⁻⁵) compared to nursery bed (0.704 g seedling⁻⁵) (Table 54).

2. At three months after sowing

At three months after sowing, the performance of the root trainers raised seedlings were significantly better than those raised in nursery bed.

i. Root length

Root length of the seedlings showed significant variation due to root trainers. The root length of the seedling grown in 600 cc root trainer was more (29.76 cm), while it was less in nursery bed (11.24 cm) (Table 55).

Table 54. Effect of root trainer on seedling growth of *A. lebbek* at one month after sowing

Root trainer size (cc)	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of nodules	Root fresh weight (g seedlings ⁻¹)	Shoot fresh weight (g seedlings ⁻¹)	Root dry weight (g seedlings ⁻¹)	Shoot dry weight (g seedlings ⁻¹)	Total dry weight (g seedlings ⁻¹)
600	23.4	11.8	0.20	9.6	28.8	0.879	3.543	0.352	1.220	1.572
300	13.8	10.5	0.19	8.0	20.0	0.796	2.325	0.319	0.778	1.097
150	10.5	9.2	0.18	7.6	10.4	0.492	2.156	0.312	0.750	1.062
Nursery bed	10.7	7.8	0.13	6.2	0.00	0.298	1.801	0.121	0.583	0.704
Mean	14.6	9.8	0.17	7.8	14.8	0.616	2.456	0.276	0.833	1.109
SEd	1.02	0.79	0.14	0.62		0.020	0.112	0.0298	0.043	0.111
CD (P=0.05)	2.16	1.7	0.03	1.31	NS	0.056	0.312	0.083	0.120	0.203

ii. Shoot length

Significant variation was noticed among root trainers for shoot length. The shoot length of the seedling raised in root trainer was more than those raised under nursery bed. Among the root trainers, 600 cc capacity recorded the longest shoot (15.82 cm) which accounted for 64 per cent increase compared to the nursery bed (9.66 cm) (Table 55).

iii. Shoot collar diameter

Significant variation was noticed for shoot collar diameter among root trainers. Compared to the seedlings raised in nursery bed, the root trainer seedlings recorded more values. The collar diameter of seedlings was more in 600 cc root trainer (0.28 cm), while it was less in nursery bed (0.14 cm) (Table 55).

iv. Number of leaves

Number of leaves varied significantly among root trainers. Root trainer raised seedlings performed better compared to nursery bed. The root trainer with 600 cc capacity recorded more number of leaves (11.9), while it was less in nursery bed (6.4) (Table 55).

v. Number of nodules

Number of nodules varied significantly among the root trainers. Among the root trainers, more number of nodules (30) was recorded in 600 cc capacity root trainer, while it was less in nursery bed (5.4) (Table 55).

vi. Root and shoot fresh weights

The fresh weights of the root ($4.052 \text{ g seedling}^{-5}$) and shoot ($6.154 \text{ g seedling}^{-5}$) of seedling raised in 600 cc root trainer were significantly higher than other root trainers. Whereas nursery bed raised seedlings recorded lower values of 0.384 and $2.102 \text{ g seedling}^{-5}$, respectively (Table 55).

Table 55. Effect of root trainer on seedling growth of *A. lebbek* at three months after sowing

Root trainer size (cc)	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of nodules	Root fresh weight (g seedlings ⁻⁵)	Shoot fresh weight (g seedlings ⁻⁵)	Root dry weight (g seedlings ⁻⁵)	Shoot dry weight (g seedlings ⁻⁵)	Total dry weight (g seedlings ⁻⁵)
600	29.76	15.82	0.28	11.9	30.0	4.052	6.154	1.902	2.726	4.640
300	19.38	14.40	0.20	9.0	21.0	3.406	5.560	1.259	2.183	3.442
150	13.50	10.12	0.18	8.0	12.6	1.747	3.056	0.759	1.062	1.821
Nursery bed	11.24	9.66	0.14	6.4	5.4	0.384	2.102	0.156	0.623	0.779
Mean	18.47	12.50	0.20	8.6	17.3	2.397	4.218	1.019	1.648	2.670
SEd	1.62	0.81	0.27	0.82	1.55	0.067	0.064	0.027	0.052	0.068
CD (P=0.05)	3.43	1.73	0.056	1.75	3.29	0.141	0.135	0.058	0.111	0.143

vii. Root and shoot dry weights

Root trainer of 600 cc capacity produced seedlings with more root (1.902 g seedling⁻⁵) and shoot dry weights (2.726 g seedling⁻⁵) in comparison with root and shoot dry weights of seedlings from nursery bed (0.156 and 0.623 g seedling⁻⁵, respectively) (Table 55).

viii. Total dry weight

Significant variation was noticed for total dry weight of seedlings due to root trainers. Seedlings raised under root trainers recorded more total dry weight compared to nursery bed. The total dry weights in 150, 300 and 600 cc root trainers were 1.821, 3.442 and 4.640 g seedling⁻⁵, respectively (Table 55).

4.4.3. Potting mixture study**i. Germination**

Significant variation was obtained for germination due to different potting mixtures. The germination was higher (67.3 per cent) in red soil : sand : goat manure. The next best treatments were red soil : sand : vermicompost (66.0 per cent) and red soil : sand : raw coir pith (65.3 per cent). The germination value of red soil : sand : FYM was 44.0 per cent (Table 56).

ii. Root length

Regarding root length, potting mixture containing red soil : sand : goat manure performed well by registering 26.2 cm. Shorter root length (13.0 cm) was registered in red soil : sand : sand. Potting mixture of red soil : sand : FYM measured root length of 25.9 cm (Table 56).

Table 56. Effect of potting mixtures on germination and growth attributes of *A. lebbek* at one month after sowing

Potting mixtures (2:1:1)	Germination (%)	Shoot length (cm)	Root length (cm)	Vigour index	Drymatter production (g seedlings ⁻⁵)
Red soil : sand : FYM	44.0 (41.6)	10.0	25.9	1581	1.844
Red soil : sand : vermicompost	66.0 (54.3)	7.0	21.3	1317	1.127
Red soil : sand : goat manure	67.3 (53.9)	10.7	26.2	2416	1.881
Red soil : sand : poultry manure	48.3 (43.9)	8.5	18.9	1315	1.285
Red soil : sand : sago waste	53.3 (46.9)	6.5	15.8	1189	0.630
Red soil : sand : sand	62.7 (52.3)	7.6	13.0	1811	1.306
Red soil : sand : vermiculite	64.7 (53.5)	7.6	16.7	1568	1.033
Red soil : sand : leaf litter compost	64.0 (53.1)	7.6	16.7	1557	1.438
Red soil : sand : raw coir pith	65.3 (55.1)	6.5	16.8	1567	1.052
Mean	59.5 (50.5)	8.0	19.0	1591	1.338
SEd	0.76	0.17	0.59	45.8	0.156
CD (P=0.05)	1.61	0.36	1.24	96.2	0.328

(Figures in parentheses indicate arc sine transformed values)

iii. Shoot length

Potting mixture containing red soil : sand : goat manure recorded the highest shoot length of 10.7 cm, whereas it was the shortest in red soil : sand : raw coir pith and red soil : sand : sago waste (6.5 cm each). Shoot length measuring 10.0 cm was recorded by red soil : sand : FYM mixture (Table 56).

iv. Vigour index

Vigour index varied significantly among treatments. The vigour index was greater (2416) in red soil : sand : goat manure and less (1189) in red soil : sand : sago waste mixture. Whereas it was 1581 in red soil : sand : FYM mixture (Table 56).

v. Drymatter production

Treatments showed significant variation for the drymatter production. Seedlings obtained from red soil : sand : goat manure registered more drymatter (1.881 g seedling⁻⁵), while it was less in red soil : sand : sago waste mixture (0.630 g seedling⁻⁵). The mixture of red soil : sand : FYM recorded a value of 1.844 g seedling⁻⁵ (Table 56).

4.4.4. Seedling grade study

4.4.4.1. Height class study

1. Initial evaluation

The root length (51.3 cm), shoot length (63.4 cm) and shoot collar diameter (0.59 cm) were higher in the tallest height class (61-75 cm). These parameters showed lesser values (32.9 cm, 21.5 cm and 0.35 cm, respectively) in the shortest height class (15-25 cm). The highest number of nodules (20.8), leaves (8.6) and nodes (13.2) were noticed in 61-75 cm height class and less (8.8, 3.4 and 5.8 respectively) in 15-25 cm height class. The tallest height class recorded higher total dry weight (9.054 g seedling⁻¹) than the shortest height class (2.186 g seedling⁻¹) (Table 57).

2. At one month after transplanting

A significant increase in shoot length, shoot collar diameter, number of leaves and nodes was observed in the tallest height class which showed an increase of 62.3, 39.1, 56.1 and 61.0 per cent over the shortest height class (Table 58).

3. At three months after transplanting

The seedling growth parameters showed significant variation among all the seedling height classes. The performance of the tallest height class (61-75 cm) was more than the rest of the seedling height classes. The root length, shoot length and shoot collar diameter for the tallest height class were 60.3 cm, 85.7 cm, and 1.18 cm, respectively. Whereas in the shortest height class, they were 35.7 cm, 30.5 cm and 0.49 cm, respectively. The number of leaves recorded 116 per cent higher values in the tallest height class compared to the shortest height class. The tallest height class registered more total dry weight (41.806 g seedling⁻¹) than the shortest seedling height class (6.671 g seedling⁻¹) (Table 59).

4.4.4.2. Diameter class study

1. Initial evaluation

Seedlings of big diameter class showed more root length (43.8 cm), shoot length (54.8 cm) and shoot collar diameter (0.58 cm) than the small diameter class (28.4 cm, 26.8 cm and 0.31 cm, respectively). Higher number of nodules (7.6), leaves (8.8) and nodes (15.2) were also registered by big diameter class and lower values (2.8, 4.0 and 9.0, respectively) in small diameter class. The total dry weight was more (7.301 g seedling⁻¹) in big diameter class and less (2.139 g seedling⁻¹) in small diameter class (Table 60).

Table 57. Effect of seedling height class on growth of *A. lehbeck* at initial evaluation

Seedling height class	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of nodules	Number of leaves	Number of nodes	Shoot dry weight (g seedling ⁻¹)	Root dry weight (g seedling ⁻¹)	Total dry weight (g seedling ⁻¹)
15 - 25 cm	32.9	21.5	0.35	8.8	3.4	5.8	0.866	1.320	2.186
26 - 45 cm	40.5	39.5	0.41	12.4	5.0	6.8	1.887	2.589	4.476
46 - 60 cm	45.2	51.1	0.47	16.4	7.6	10.8	4.611	2.926	7.537
61 - 75 cm	51.3	63.4	0.59	20.8	8.6	13.2	5.611	3.443	9.054
Mean	42.5	43.9	0.46	14.6	6.2	9.2	3.243	2.570	5.813
SEd	0.67	1.43	0.023	0.63	0.37	0.53	0.048	0.226	0.274
CD (P=0.05)	1.41	3.03	0.048	1.34	0.79	1.12	0.101	0.480	0.581

Table 58. Effect of seedling height class on growth of *A. lehbeck* at one month after transplanting

Seedling diameter class	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of nodes
15 - 25 cm	25.0	0.42	5.8	9.8
26 - 45 cm	47.3	0.57	7.4	12.2
46 - 60 cm	55.0	0.56	9.6	13.6
61 - 75 cm	66.4	0.69	13.2	15.8
Mean	48.4	0.56	9.0	12.8
SEd	0.77	0.022	0.50	0.58
CD (P=0.05)	1.62	0.046	1.06	1.24

Table 59. Effect of seedling height class on growth of *A. lebbek* at three months after transplanting

Seedling height class	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Root dry weight (g seedling ⁻¹)	Shoot dry weight (g seedling ⁻¹)	Total dry weight (g seedling ⁻¹)
15 - 25 cm	35.7	30.5	0.49	6.4	2.731	3.940	6.671
26 - 45 cm	49.0	64.9	0.69	7.4	8.894	7.936	16.830
46 - 60 cm	54.2	73.4	0.86	9.8	16.578	16.213	32.791
61 - 75 cm	60.3	85.7	1.18	13.8	21.045	20.761	41.806
Mean	49.8	63.6	0.81	9.4	12.312	12.213	24.525
SEd	0.64	0.91	0.041	0.45	0.377	0.352	0.729
CD (P=0.05)	1.36	1.94	0.087	0.95	0.798	0.746	1.544

2. At one month after transplanting

After one month of transplanting, the seedlings gave a significant increase in big diameter class for shoot length, shoot collar diameter, and number of leaves and nodes which showed 48.0, 44.8, 45.1, and 42.0 per cent increase respectively over small diameter class (Table 61).

3. At three months after transplanting

Seedlings of big diameter class showed a significant increase over small diameter class in all the seedling parameters. Seedlings of big diameter class recorded more root length (51.9 cm), shoot length (80.0 cm) and shoot collar diameter (1.18 cm) compared to small diameter class (30.4 cm, 31.7 cm and 0.56 cm, respectively). Number of leaves per seedlings was more (13.8) in big diameter class than the small diameter class (6.2). The root and shoot dry weights were more in seedling of big diameter class (17.578 and 14.233 g seedling⁻¹, respectively) compared to small diameter class seedlings (2.041 and 2.106 g seedling⁻¹, respectively). Seedlings of big diameter class registered more total dry weight (31.811 g seedling⁻¹). Whereas it was low in seedlings from small diameter class (4.147 g seedling⁻¹) (Table 62).

Table 60. Effect of seedling diameter class on growth of *A. lebbek* at initial evaluation

Seedling diameter class	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of nodules	Number of leaves	Number of nodes	Shoot dry weight (g seedling ⁻¹)	Root dry weight (g seedling ⁻¹)	Total dry weight (g seedling ⁻¹)
0.21 – 0.35 cm	28.4	26.8	0.31	2.8	4.0	9.0	0.907	1.232	2.139
0.36 – 0.50 cm	34.0	39.4	0.42	5.2	7.0	12.6	2.038	2.573	4.611
0.51 – 0.65 cm	43.8	54.8	0.58	7.6	8.8	15.2	4.391	2.910	7.301
Mean	35.4	40.3	0.44	5.2	6.6	12.4	2.445	2.258	4.683
SEd	0.61	0.75	0.016	0.48	0.48	0.61	0.046	0.158	0.204
CD (P=0.05)	1.34	1.63	0.034	1.04	1.04	1.33	0.101	0.343	0.444

Table 61. Effect of seedling diameter class on growth of *A. lebbek* at one month after transplanting

Seedling diameter class	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Number of nodes
0.21 – 0.35 cm	29.6	0.37	5.6	11.6
0.36 – 0.50 cm	42.7	0.49	8.2	15.8
0.51 – 0.65 cm	56.9	0.67	10.2	20.0
Mean	43.1	0.51	8.0	15.8
SEd	0.50	0.011	0.70	0.77
CD (P=0.05)	1.08	0.025	1.53	1.69

Table 62. Effect of seedling diameter class on growth of *A. lebbek* at three months after transplanting

Seedling diameter class	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Number of leaves	Root dry weight (g seedling ⁻¹)	Shoot dry weight (g seedling ⁻¹)	Total dry weight (g seedling ⁻¹)
0.21 – 0.35 cm	30.4	31.7	0.56	6.2	2.041	2.106	4.147
0.36 – 0.50 cm	44.4	46.9	0.73	8.4	7.097	10.347	17.444
0.51 – 0.65 cm	51.9	80.0	1.18	13.8	17.578	14.233	31.811
Mean	42.2	52.9	0.82	9.4	8.905	8.896	17.801
SEd	0.55	0.88	0.013	0.60	0.214	0.188	0.402
CD (P=0.05)	1.20	1.93	0.029	1.31	0.465	0.409	0.874

DISCUSSION

CHAPTER V

DISCUSSION

Provenance is the place in which any stand of trees is growing (OECD, 1974). It is the geographic source or location to which plants are native and within which their genetic characteristics have been developed through natural selection (Zumer-Linder, 1979). Seeds are influenced by their place of birth (Heydecker, 1972) especially due to environmental variations in latitude, altitude, rainfall, temperature, moisture, soil, daylength and other factors (Holzer, 1965, Mathur *et al.*, 1985, Padmini and Banerjee, 1986).

The seed source variation was reported on many tree species and are dictated by environmental and edaphic factors. This may also be due to altitudinal variation (Barnett and Farmer, 1978) or region of collection (Bonner, 1984). Hence, best provenance has to be selected to screen the natural and environmental variations and to choose the best available sources for seed collection. The selection of plus trees and provenance is the first step in the series of stages involved in the tree improvement programme.

5.1. SELECTION OF CANDIDATE PLUS TREES (CPTs)

The aim of selecting CPTs is to find out the best genetic material among the trees available because it is the only possible means to observe the phenotype of the tree (Jayaraj, 1997). Hence, efforts were taken to demarcate of the CPTs *A. lebbek* based on their morphometric characters viz. Girth at Breast Height (GBH), tree height and Clean Bole Height (CBH) in all the prominent tree sources of Tamil Nadu.

Twelve seed sources of *A. lebbek* were included in the present study. The GBH ranged from 128.3 to 288.6 cm, tree height from 12.6 to 23.7 m and CBH from 1.9 to

3.7m. Among the seed sources, Anamalai WLS recorded the highest GBH (288.6 cm) and tree height (23.7 m), while Ramanathapuram recorded the highest CBH (3.7m). Coimbatore, Arupukottai and Tirunelveli ranked second for GBH, height and CBH, respectively. The respective values were 198.2cm, 21.6m and 3.6m. Aliyar recorded the lowest GBH (128.3cm), while tree height (12.6m) and CBH (1.9m) were the lowest in Chinglepet source (Fig.2). Based on the morphometric characters, it is concluded that Anamalai WLS and Coimbatore seed sources possessed superior CPTs.

5.2. EFFECT OF SEED SOURCE ON SEED QUALITY

5.2.1. Physical characteristics of seed

Seed physical characters are strongly related to the physiological potential of the seed. Several authors have made affirmative statements on the positive influence of seed size and weight over seed germinability (Bonner and Switzer, 1971; Ponnusamy *et al.*, 1991; Mononmani *et al.*, 1996; Manonmani and Vanangamudi, 1997). Several authors have reported on the ecological influence on the seed characteristics (Joshi *et al.*, 1983 in *Acacia nilotica*; Kumaran, 1991, Sivasamy and Karivaratharaju, 1993, Umarani *et al.*, 1993 and Sivagnanam *et al.*, 1997 in *Azadirachta indica*; Arya *et al.*, 1993 in *Tecoma undulata*; Jenner, 1995 in *Madhuca latifolia*; Manonmani and Vanangamudi, 1997b in *Tectona grandis*).

In the present study, the seed length (10.7 mm) was more in Ramanathapuram, while it was less (8.33mm) in Tirunelveli. Coimbatore source ranked first for seed breadth (7.9 mm), individual seed weight (143 mg) and hundred seed weight (13.500 mg) (Fig.3). Madurai and Chinglepet for seed breadth (6.65 mm), and Ramanathapuram and Trichy for individual seed weight (103 mg) and Anamalai WLS for hundred seed weight (8.018g) showed the least values. Seed thickness was more in Chinglepet (2.60 mm) and less in Salem (1.9mm).

Fig.2. Mean morphometric traits for CPTs of *A. lebbek* in different seed sources

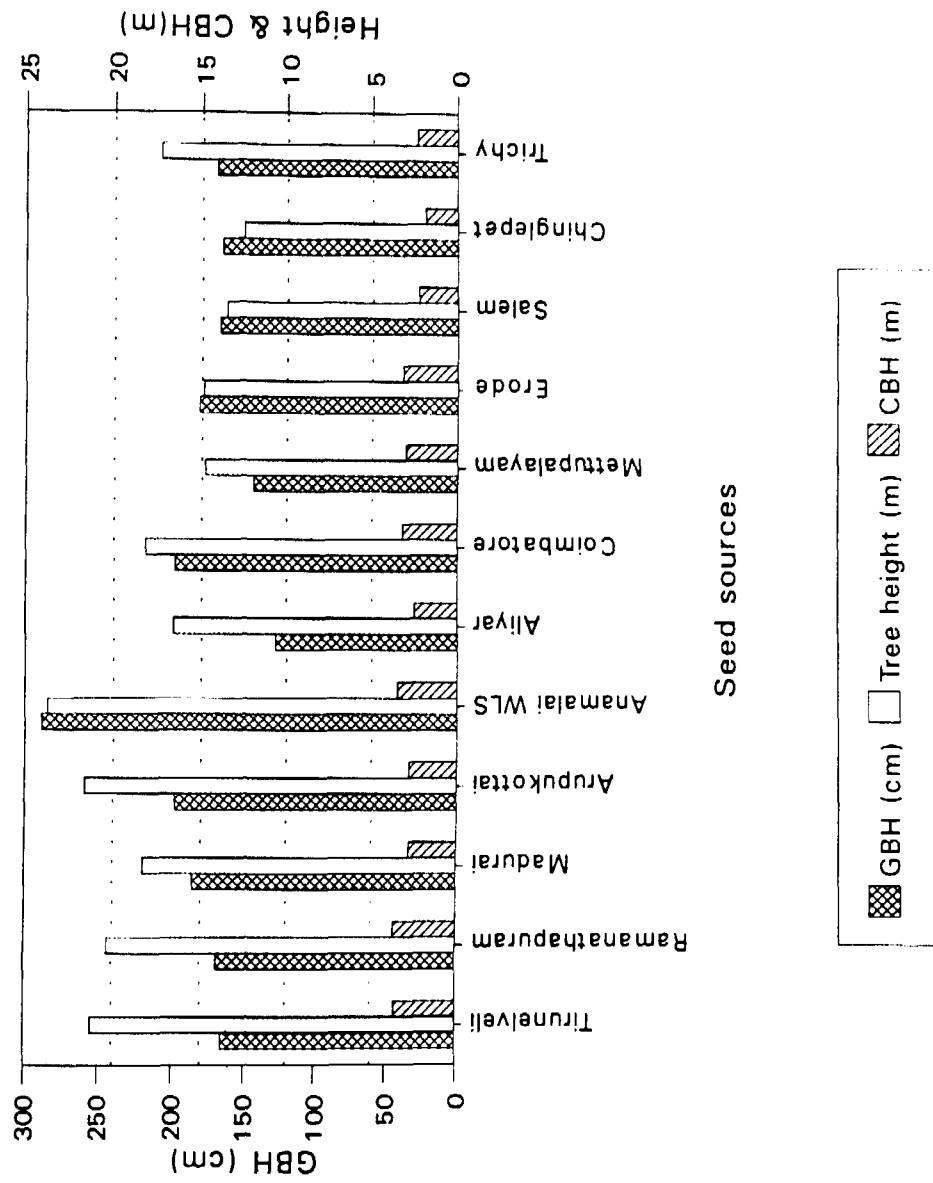
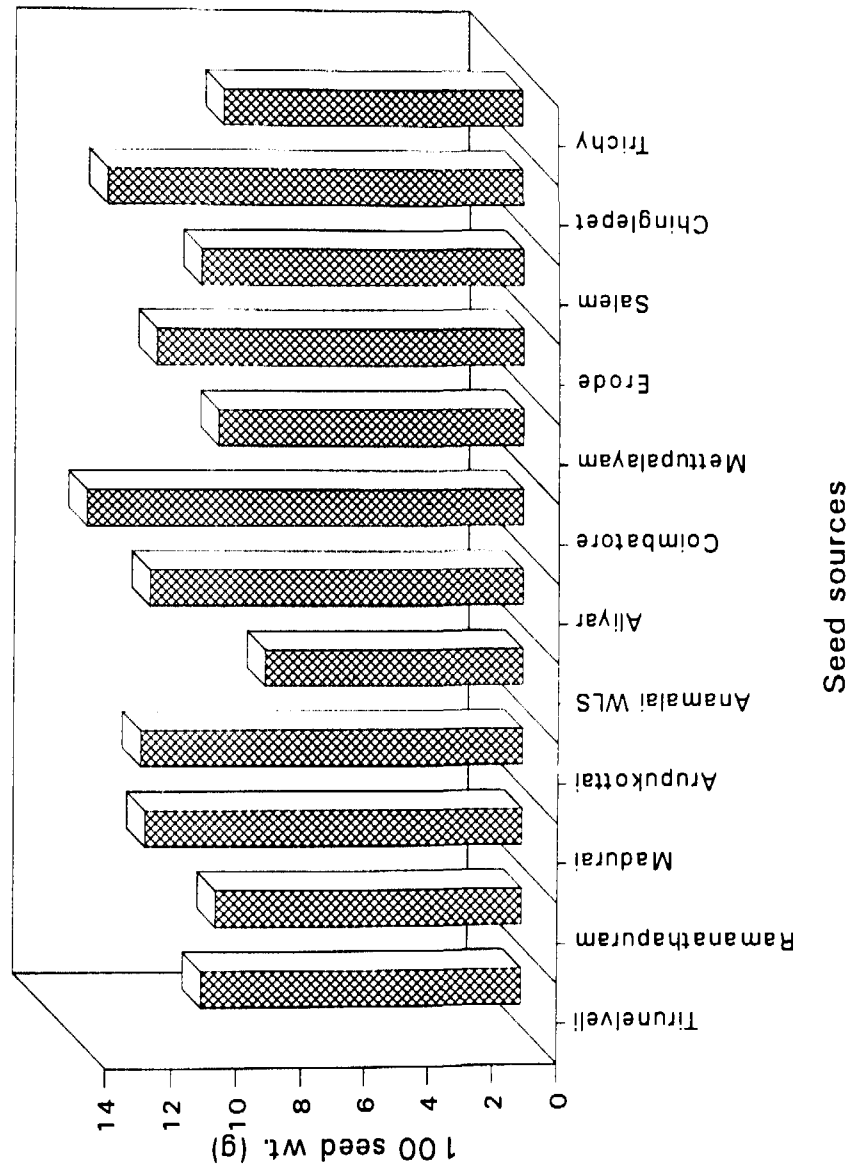


Fig.3. Effect of seed source on 100 seed weight of *A. lebbek*



Seed physical characters observed for *A. lebbek* revealed that most of the traits viz., seed breadth, individual and hundred seed weight showed higher values for the seeds collected from Coimbatore.

Similar variations in physical parameters due to sources were reported in teak (Murthy, 1973; Manonmani and Vanangamudi, 1997b), sandal (Srimathi *et al.*, 1977; Srimathi and Kulkarni, 1982; Bagchi and Sharma, 1989; Manonmani, 1997), neem (Kumaran, 1991; Sindhu, 1995), *A. lebbek* (Toky *et al.*, 1996), amla, jamun and ber (Srimathi, 1997) and *Acacia nilotica* (Vanangamudi *et al.*, 1998c).

The insect damage by *Bruchus sparsimaculatus* was less in Aliyar (1.0 per cent) and higher in Trichy (15.8 per cent) seed source. The insect damage by the bruchid (*B. sparsimaculatus*) was also recorded in *A. lebbek*, (Ponnusamy *et al.*, 1990; Satya Vir and Jindal, 1997 and Bedell, 1998) as well as in *Prosopis cineraria* and *Acacia senegal* (Satya Vir and Jindal, 1997).

5.2.2. Physiological parameters of seed

The study of seed physical characters has to be correlated with the physiological potential of the seeds. It includes germination potential, nursery performance and field performance after outplanting, which alone can serve as the perfect method to delineate or demarcate the best seed sources. Hence, a detailed study was planned to study the physiological potential of the seeds collected from various sources.

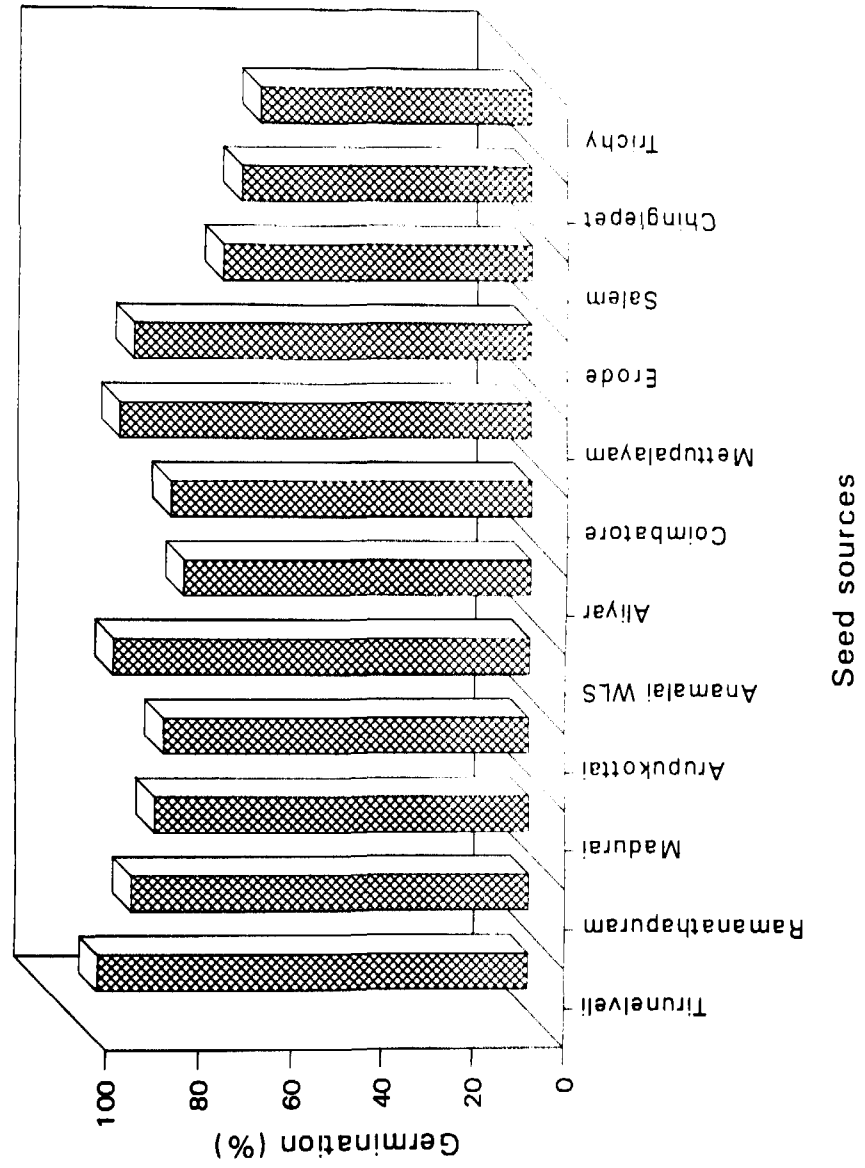
In the present study, significant variations were noticed for germination among the seed sources. The higher seed germination was obtained in Tirunelveli (94.0 per cent) and Anamalai WLS (91 per cent) seed sources and they belong to Southern and Western agroclimatic zones, respectively (Fig.4). This suggests that environmental and

physiographic conditions play an important role in deciding survival and establishment of seeds. Variation in germination due to seed source was also reported in *Acacia senegal* (Gupta *et al.*, 1973); *Tectona grandis* (Gupta and Pattanath, 1975; Manonmani, 1997; Manonmani and Vanangamudi, 1997b); *Liriodendron tulipifera* (Barnett and Farmer, 1978); *Cedrus deodora* (Thapliyal and Gupta, 1980); *Azadirachta indica* (Ezhumah, 1986; Sivasamy, 1991; Kumaran, 1991); *Pongamia pinnata* (Kumaran, 1991; Manonmani *et al.*, 1996); *A. nilotica* (Suresh, 1994) and *Madhuca latifolia* (Jenner, 1995). However, Sivagnanam (1995) and Sivagnanam *et al.* (1997) in *A. indica* and Vanangamudi *et al.* (1998c) in *A. nilotica* did not find any variation in germination due to seed sources.

Statistically significant variations were noticed among seed sources for the root length, shoot length, shoot collar diameter, number of nodules and total dry weight. Considering the root length of the nursery seedling, Coimbatore (32.2 cm) followed by Aliyar (27.5 cm) seed source recorded more root length than rest of the sources in two months period, while Coimbatore (49.00 cm and 49.42 cm) followed by Madurai (44.7 and 47.63 cm) showed better performance both at four and six months after sowing. Arupukottai with 43.3 cm ranked next to Madurai at four months after sowing. Trichy source registered shorter root length (15.6cm) at two months stage, whereas at four and six months Chinglepet (21.2 cm) and Trichy (28.7 cm) registered shorter root length, respectively.

Arupukottai outperformed rest of the sources with 21.1 cm, 27.8 cm and 31.57 cm respectively, at two, four and six months after sowing for shoot length. The next closest source was Tirunelveli (16.06 cm), Madurai (26.4 cm) and Salem (31.37 cm), respectively.

Fig.4. Seed germination as influenced by seed source in *A. lebbek*



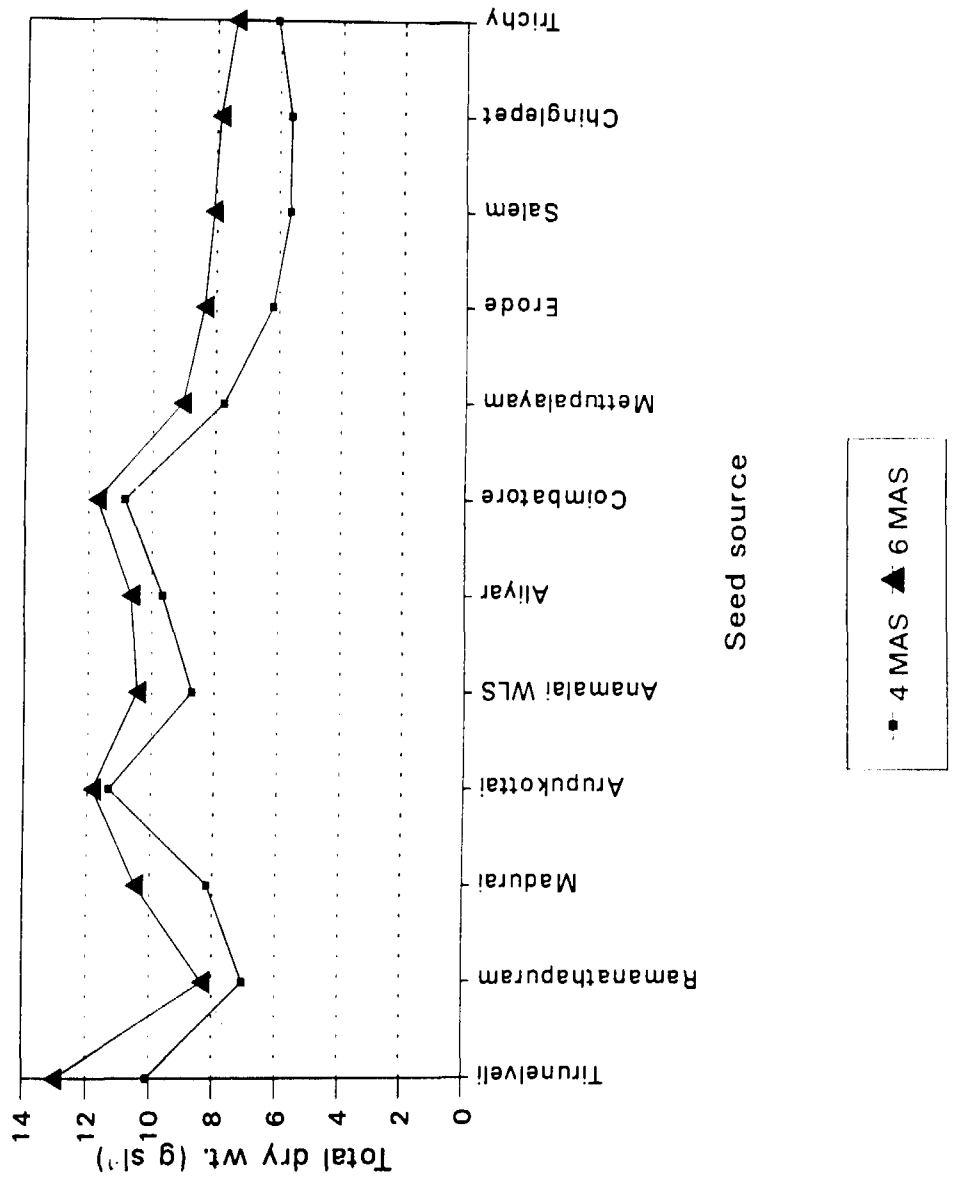
Performance of shoot collar diameter was higher in Tirunelveli and Aliyar in two, four and six months after sowing. Whereas shoot collar diameter of seedlings from Erode and Salem registered the lowest values.

Madurai (34.4) followed by Coimbatore (33.6) recorded more number of nodules in two months period. After four and six months of sowing, Coimbatore (37.3 and 40.3) followed by Madurai (33.3 and 34.3) recorded higher values. Nodule number was found to be lesser in Ramanathapuram at four and six months stages. Compared to other sources, the total dry weight was found to be more in Arupukottai, Coimbatore and Tirunelveli sources at four as well as six months after sowing (Fig 5).

Hence it is concluded that Arupukottai, Madurai and Tirunelveli from Southern zone as well as Coimbatore and Aliyar from Western zone are the best sources for good germination and high quality seedling production.

Variation in root and shoot lengths, and vigour index due to seed source under laboratory conditions was also reported in *A. nilotica* by Vanangamudi *et al.* (1998). Under nursery conditions also similar variation in seedlings growth and biomass of teak due to seed source were evident (Manonmani and Vanangamudi, 1997). Mani *et al.* (1997) recorded more root length, shoot length, drymatter, germination value and vigour index for gardenland source under laboratory conditions. In the nursery conditions also garden land source proved its superiority over other sources in seedling height, shoot collar diameter, root weight and drymatter production. From this study, it is concluded that gardenland and tankbed (open) sources are the best for collection of good quality seeds for elite seedling production in *Acacia nilotica*.

Fig.5. Total dry weight of *A. lebbek* seedlings as influenced by seed sources under nursery conditions



5.2.3. Survival and establishment

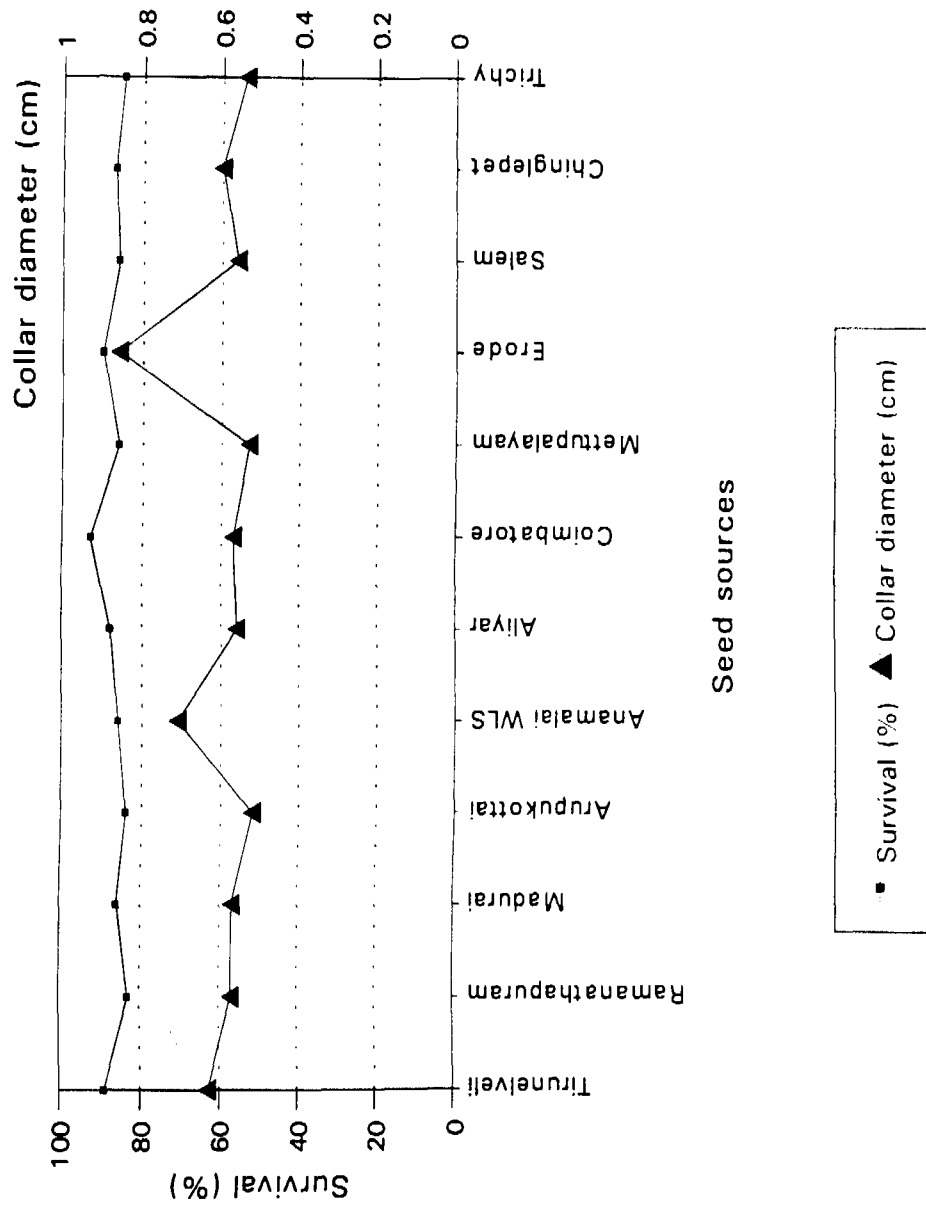
After evaluating the germination potential and the growth performance in the nursery, the seedlings were outplanted and observed for their survival and establishment. In this study after three months of planting, the seeds collected from Western zone exhibited superiority for establishment and growth than other zones. Coimbatore seed source recorded 93 per cent of survival in the field and it accounted for 10 per cent increase over Ramanathapuram which recorded minimum survival (Fig. 6). Regarding plant height Mettupalayam seed source registered maximum of 48.0 cm which was on par with Aliyar (47.6 cm) and Erode (46.9 cm) and the minimum was found in Trichy 29.7 cm. Erode seed source noticed the largest shoot collar diameter (0.86 cm) (Fig. 6) which showed a 39.5 per cent increase over Arupukottai seed source, which recorded the smallest shoot collar diameter.

Larger variation in growth characteristics of loblolly pine (*Pinus taeda*) was noticed among seed sources by Wells and Wakeley (1966). Similar results were also reported by Pipatwattanakul (1989) and Sukhat Lawskul (1991) in *Acacia mangium*, Triwahyono and Mamber (1991) in *Calliandra calothyrsus* and Paudel *et al.* (1996) in *Pinus patula*.

5.2.4. Performance of seed source under stress conditions

Performance of seed sources under stress conditions viz., high acidity, alkalinity, salinity and drought is an important test on the physiological potential of the sources to screen their superiority for specific condition. Accelerated aging is highly related to the vigour of seed lot and hence to the capacity of the lots to perform well under field conditions (ISTA, 1993). Testing the seeds under low or high pH has also been recommended as a stress test. The vigour test helps to differentiate the lots that have same

Fig.6. Performance of different seed sources of *A. lebbek* seedlings in the field



germination percentage but with differential responses in field emergence and seedling vigour.

Though the results of the studies to evaluate the seed source response to various stress conditions are not available in tree species to support the findings of the present study, the results of few studies on the response of different agroforestry tree species to stresses are used here to support the findings of this study.

Seed sources exhibited variation in resistance towards salts stress. Among, the concentrations of NaCl used viz., 0.25, 0.50, 0.75 and 1.0%. Coimbatore recorded the lowest percentage of reduction for germination (45.7) in both 0.75% and 1.0% concentrations, which was followed by Erode. Trichy recorded the lowest tolerance to salt stress by recording the highest percentage decrease (56.5), which was followed by Chinglepet (Fig. 7). Salem recorded the lowest percentage of reduction for root length at 1.0% concentration (38.8) followed by Erode (39.5) and Coimbatore (40.36), while Ramanathapuram recorded the highest percentage of reduction (42.8). For vigour index, Coimbatore (66.8) and Erode (68.2) recorded the lowest percentage of decrease over control, when irrigated with higher concentration of salt (1.0%). The highly affected seed sources were Madurai (75.8) and Trichy (73.7). The lowest percentage of decrease over control for drymatter production was observed in the Coimbatore source (35.9) followed by Salem (36.1) and Chinglepet (36.1), when irrigated with 1.0% concentration of salt.

A significant decline in germination, seedling vigour and biomass was noticed in various tree species as the salinity levels increased (Singh *et al.*, 1991; Gupta *et al.*, 1987; Sharma *et al.*, 1992; Yadava and Om Prakash, 1995; Kathiresan *et al.*, 1996; Sharma *et al.*, 1998). This could be attributed to osmotic effect

of NaCl limiting seed hydration and toxic effect of NaCl on seed embryo or endosperm cell membranes (Ayers, 1952; Bliss *et al.*, 1986).

In the present study, the pH of the sand medium had a significant effect on the germination percent of the seed however, the response varied with the seed source. The Tirunelveli source (21.6) recorded the lowest percentage of reduction in germination at a pH of 10 over the control. This was followed by Coimbatore (25.6). The most affected source was Aliyar (46.2) (Fig. 8). Tirunelveli and Coimbatore sources proved superior with respect to root length, drymatter production and vigour index also.

Kathiresan and Thangam (1990) and Kathiresan *et al.* (1996) reported that neutral pH favoured better seedling growth characters, while low and high pH levels inhibited the growth parameters in *Rhizophora* spp.

With respect to PEG test also, the best source was Coimbatore which recorded the lowest percentage of decrease for germination at concentration of 1.25%. Chinglepet recorded the least tolerance towards stress imparted by Poly Ethylene Glycol (Fig. 9). The Coimbatore seed source also registered superiority with respect to drymatter production (14.2), vigour index (7.9) and root length (9.0), which recorded low percentage of decrease over the control.

In neem, Vanangamudi *et al.* (1998) reported that PEG soaking at 0.25%, 0.50% and 0.75% concentration maximised germination by 9.0 per cent. Higher concentrations of 1.0%, and 1.25% proved ineffective. PEG did not influence the seedling growth at any level of concentrations.

Fig.7. Response of different seed sources to NaCl salt stress test

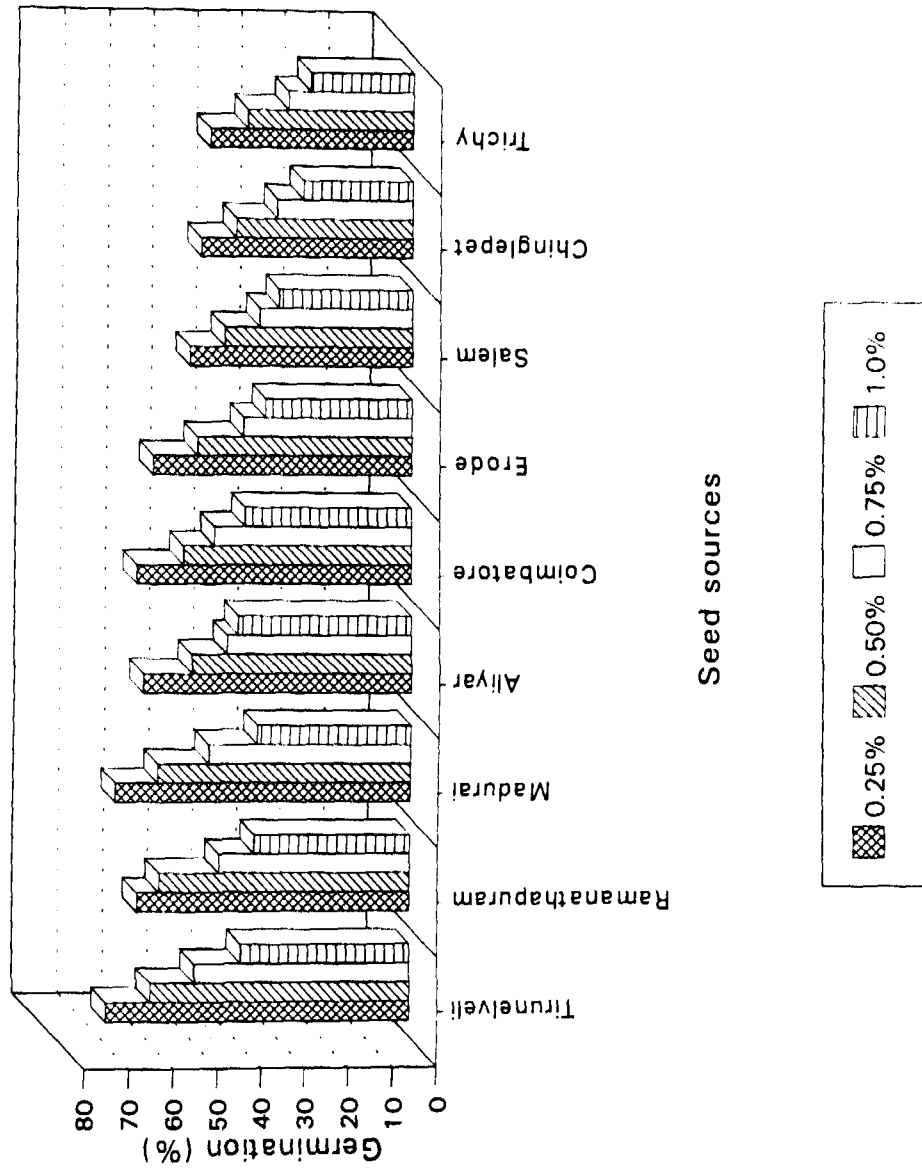


Fig.8. Response of different seed sources to pH test

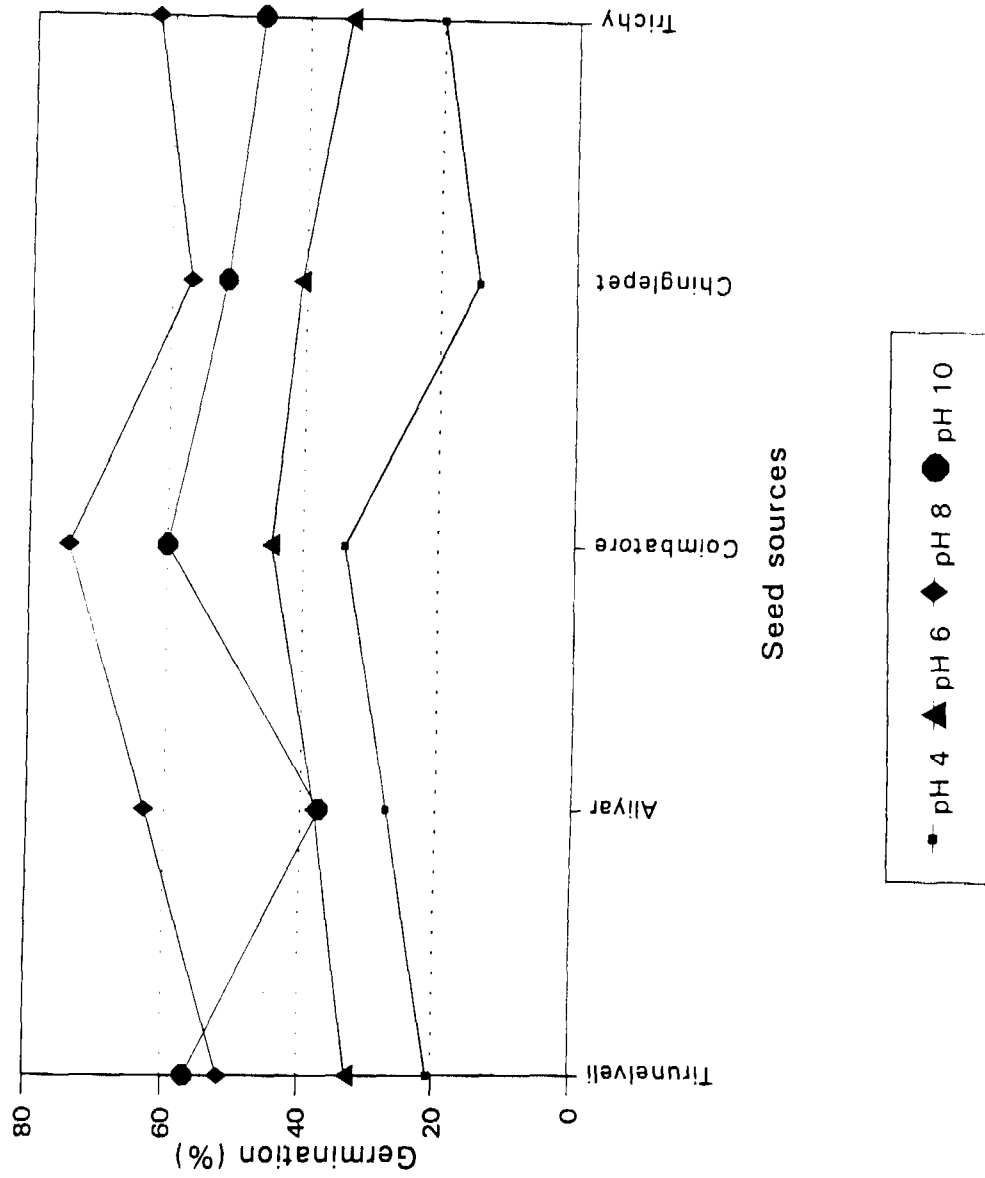
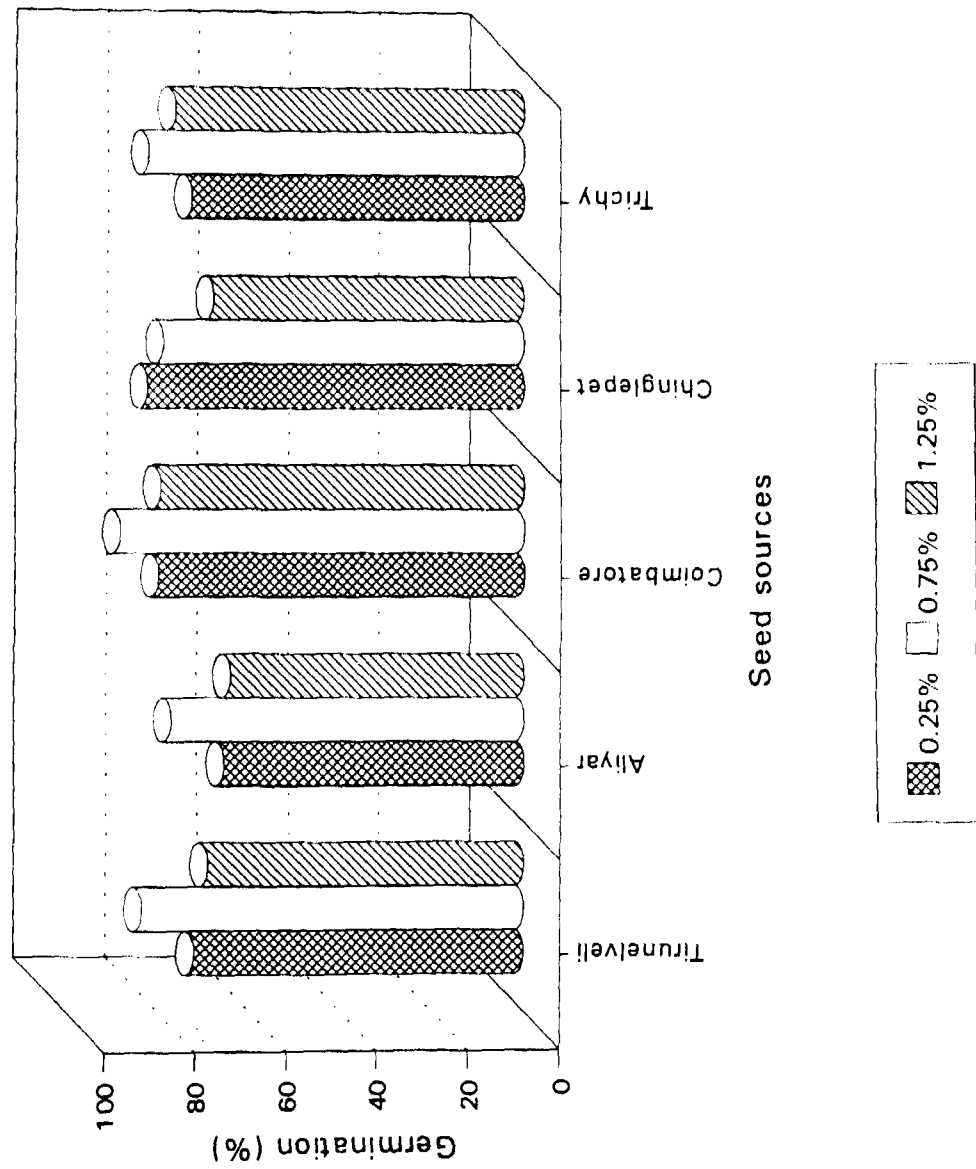


Fig.9. Response of different seed sources to PEG test



The accelerated aging test according to AOSA (1983) might be a reliable test to assess whether seeds should be sown immediately or could be stored. Though used extensively in arable crops, this test has been applied in only a few tree species (Bonner, 1974; Pitel 1980; Blanche *et al.*, 1988; Malta and Blanche, 1989).

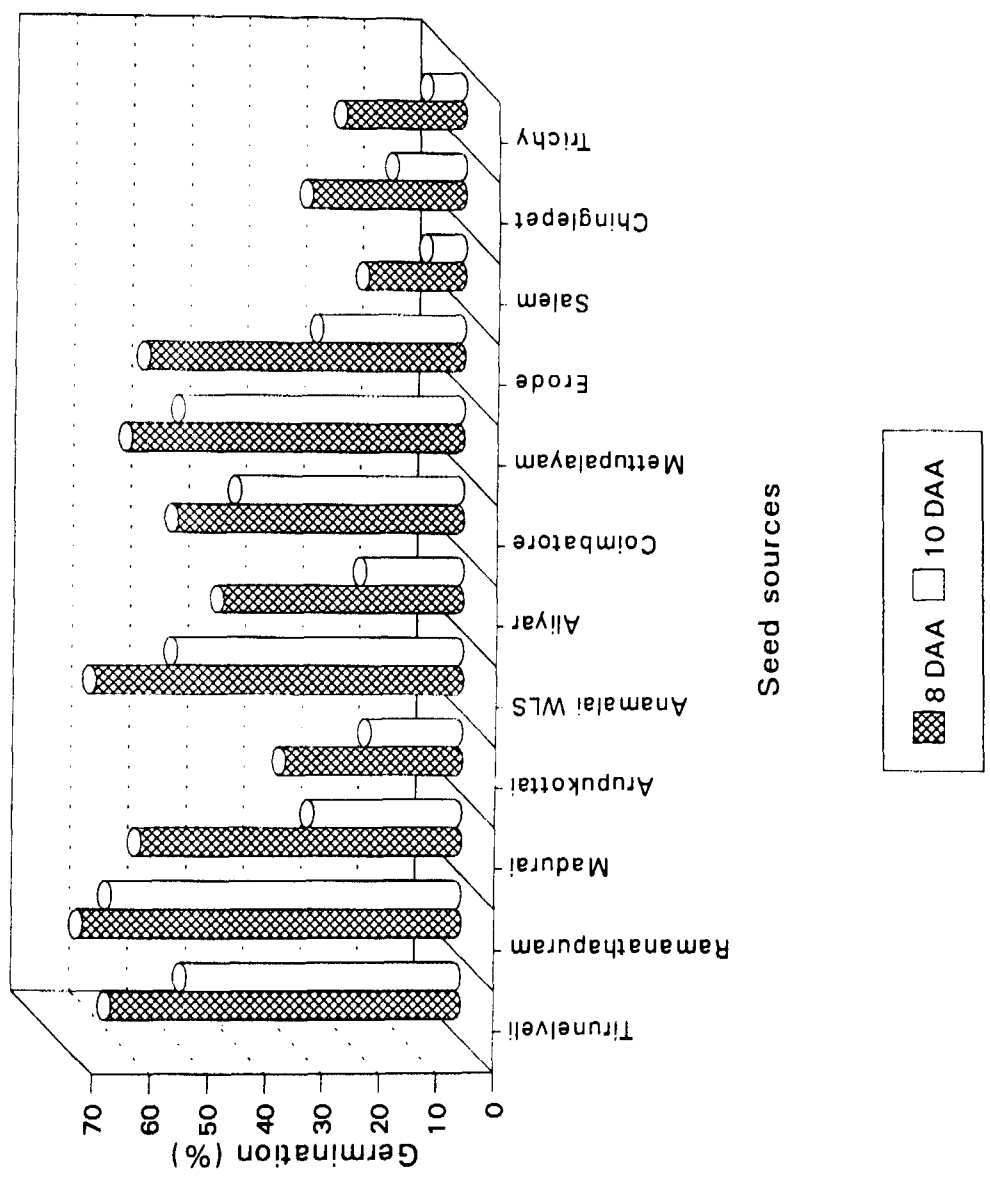
As far as accelerated aging was concerned, among the seed sources, Ramanathapuram recorded the smallest decrease over control (31.5) in germination percentage after 10 days of accelerated aging followed by Anamalai WLS (44.4). The highest decrease over control after 10 days of accelerated aging was recorded by Salem (91.3) followed by Trichy (90.7) (Fig. 10).

With respect to root length, the Coimbatore (28.9) and Tirunelveli (31.6) recorded lower percentage of reduction over control after 10 days of accelerated aging. The lowest decrease in percentage over control for vigour index was observed in Ramanathapuram (54.4) and Tirunelveli (64.5) after 10 days of accelerated aging. Salem (95.4) and Trichy (95.2) recorded the highest percentage of decrease.

Vanangamudi *et al.* (1997) stated that neem and jamun behaved differently for viability and seedling vigour for accelerated aging test. The germination percentage dropped to less than 50 on the fourth day after aging in jamun, whereas it took six days for neem. None of the jamun seed germinated even after seven days however, neem could germinate until ten days. Seedling vigour was quickly affected in neem than in jamun. It is therefore, concluded that both the seeds of neem and jamun should be sown in the nursery immediately after collection.

The experiments under stress conditions revealed that Coimbatore and Aliyar sources are the best suited to salinity conditions. Coimbatore and Aliyar sources can

Fig. 10. Response of different seed sources to accelerated aging test



tolerate pH at acidic range, while Tirunelveli and Coimbatore sources can withstand alkaline range of pH. The sources which withstood the stress of accelerated aging are Ramanathapuram and Anamalai WLS. At high concentration of PEG, the seed sources viz., Coimbatore and Tirunelveli could perform better. The seeds sources which showed the lowest tolerance to salinity, acidity, alkalinity, accelerated ageing and high PEG concentration were Trichy, Chinglepet, Aliyar, Salem and Chinglepet, respectively

5.3. SEED TESTING RULES

Testing of the quality and other characteristics of seed needs to be made at several stages i.e., from the parent tree to the seed bed. Efficiency and success in raising seedlings in the nursery and their subsequent establishment in forest plantations depend to a great extent on the quality of the seeds used.

Justice (1972) has defined the following objectives for developing rules for seed testing, (a) to provide methods by which the quality of seed samples can be determined accurately, (b) to prescribe methods by which seed analysts working in different laboratories in different countries throughout the World can obtain uniform results, (c) to relate the laboratory results insofar as possible, to planting value, (d) to complete the tests within the shortest period of time possible, commensurate with the above mentioned objectives, and (e) to perform the tests in the most economical manner

Although tree species and genera from the tropics and southern hemisphere (notably *Eucalyptus*) have begun to figure in the ISTA lists, the balance is still overwhelmingly weighted towards north temperate species. Many important tropical tree species are not included at all. Their omission simply reflects the lack of reliable information from research on the best methods of testing these species and genera (ISTA, 1993).

For standardizing the seed testing procedures for *A. lebbek*, the seeds collected from twelve seed sources were treated as twelve seed lots and this has been used in the subsequent discussion of results.

5.3.1. Weight of the submitted and working sample

The weight of the working sample depends on the seed size of the species in question. The ISTA rules are intended to provide a minimum of 2500 seeds for all except the very large seeded species, for which a minimum of 500 seeds is prescribed. These quantities are considered sufficient for most of the usual tests (purity, authenticity, seed weight and germination), but an additional 10g of most species is needed if moisture content is to be determined. The weight of the submitted sample should be double to that of the working sample (ISTA, 1993). Among tropical species listed by ISTA the prescribed minimum size of working sample ranged from 2g for *Eucalyptus deglupta* to 1000g for *Tectona grandis*.

In the pursuit of standardizing the weight of submitted and working samples, total of twelve seed lots were used. The weight of 2500 seeds ranged from 232.430 to 338.110 g with an average of 276.15 g. It is hence, standardized from the above observations that the working sample size is 276 g.

Ten times of working sample weight is the submitted sample weight. The weight of submitted sample is arrived as 2762 g but subjected to a maximum of 1000 g (ISTA, 1993) the of submitted sample is reported as 1000 g. Measurement of seed weight is made on the pure seed component separated by the purity analysis. ISTA (1993) prescribes eight replications of 100 seeds each, from which the standard deviation and coefficient of variation may be calculated, as well as the mean. If the coefficient of variation is less than 4, the mean is accepted, but if it is more, 8 additional replicates are

prescribed, a new standard deviation for the 16 replicates calculated and any replicate that diverges from the mean by more than twice the standard deviation is discarded before calculating the final mean for the sample.

Efforts were taken to determine the hundred seed weight of *A. lebbek* by observing in twelve seed lots. The hundred seed weight ranged from 8.018 to 13.500 g, with an average of 10.776 g. It was observed from the statistical analysis that the standard deviation calculated was below 4 (0.231) (ISTA, 1993). Therefore, the hundred seed weight is reported as 10.776 g.

5.3.2. Purity analysis

Tree seed sample can contain impurities such as weed seeds, seeds of other tree species, detached seed structures, leaf particles and other material. The object of purity analysis is to determine the composition by weight of the sample being tested. To do this, the sample is separated into component parts. When purity analysis is done, it is the first test to be carried out because subsequent tests are made only on the pure seed component (ISTA, 1993).

Purity analysis was done using twelve seed lots of *A. lebbek*. The pure seed fraction ranged from 98.3 to 99.6 per cent with an average of 99.1 per cent. Hence, it is concluded that any seed lot of *A. lebbek* should possess a pure seed fraction of more than 99 per cent.

5.3.3. Germination test requirements

Of all quality measurements of seed lots, none is more important than the potential germination of the seeds (Bonner, 1974). The main aim of a laboratory germination test is to estimate the maximum number of seeds which can germinate in optimum conditions.

The use of standardized ideal conditions in the laboratory such as those prescribed by ISTA ensures that results obtained from a given seed lot in one laboratory should be identical with those obtained from any other laboratory in the same or in other countries

5.3.3.1. Pre-treatments for breaking dormancy

A. lebbek seeds exhibit a germination percentage of 80 per cent. Reports reveal that the seeds possess dormancy viz., hardseededness (Kaul, 1965). Therefore, treatments were formulated to overcome the dormancy and attain higher germination potential by scarifying the seeds with H₂SO₄ for different durations.

In the present study, significant variations were noticed among the different durations of acid scarification for seed germination, seedling length and vigour parameters. Compared to control, the percentage of germination increase was more in 30 min. (69) followed by 25 min. scarification (68) (Fig. 11). After 25 min. scarification, root length, shoot length, vigour index and drymatter production registered a percentage increase of 14.6, 13.0, 72.0 and 45.7 respectively over control. Hence, it is concluded that acid scarification for 25 min. is optimum for breaking dormancy and to get enhanced seedling vigour.

A study was also undertaken to improve the seed germination of *A. lebbek* apart from the dormancy breaking through acid scarification. Seeds treated with sulphuric acid scarification for 25 min. followed by 24 h water soaking registered higher increase of 42.5 per cent over control (Fig. 12). The next best treatment was acid scarification for 25 min. followed by GA₃ 200 ppm 24 h, which recorded an increase of 40.5 per cent over control. The seeds that were only acid scarified recorded an increase of 38.5 per cent only. Hence, it is concluded that enhanced seed germination could be obtained by scarifying the seeds with sulphuric acid for 25 min. + 24 h water soaking.

Fig. 11. Improvement of germination due to acid scarification

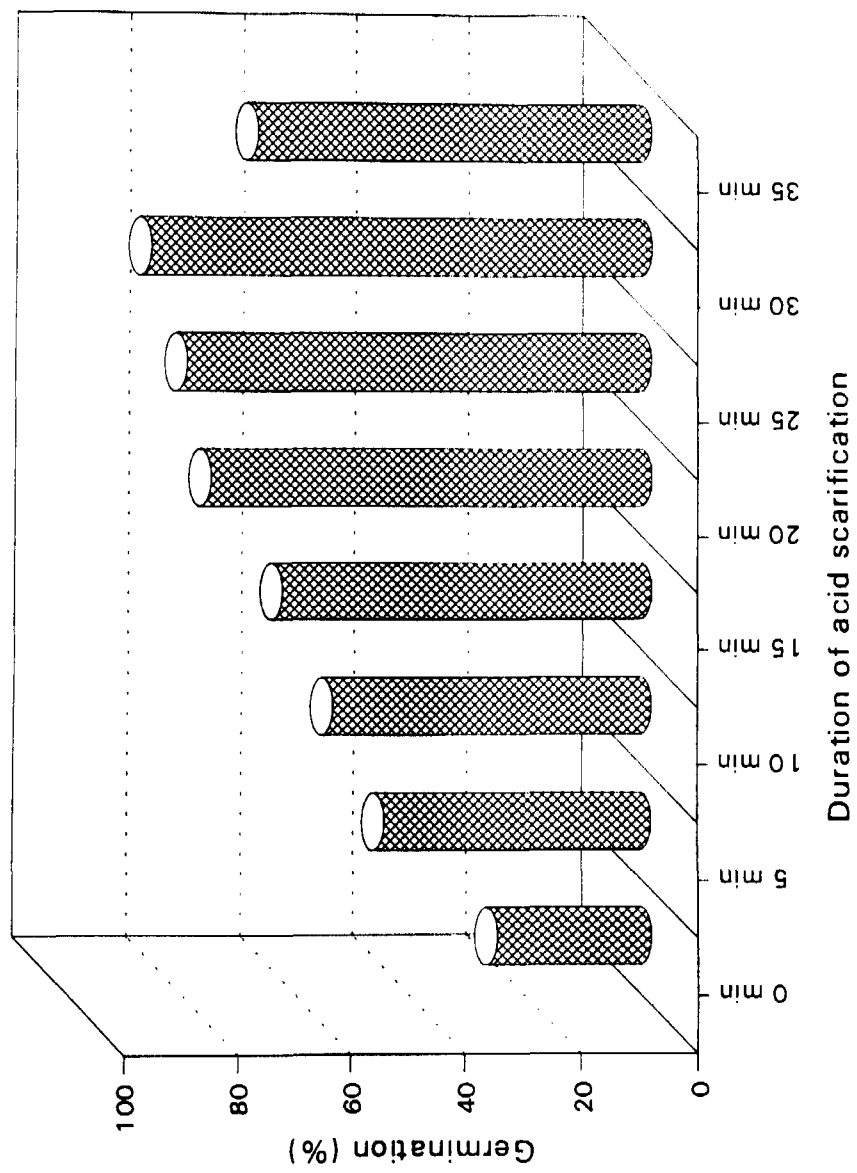
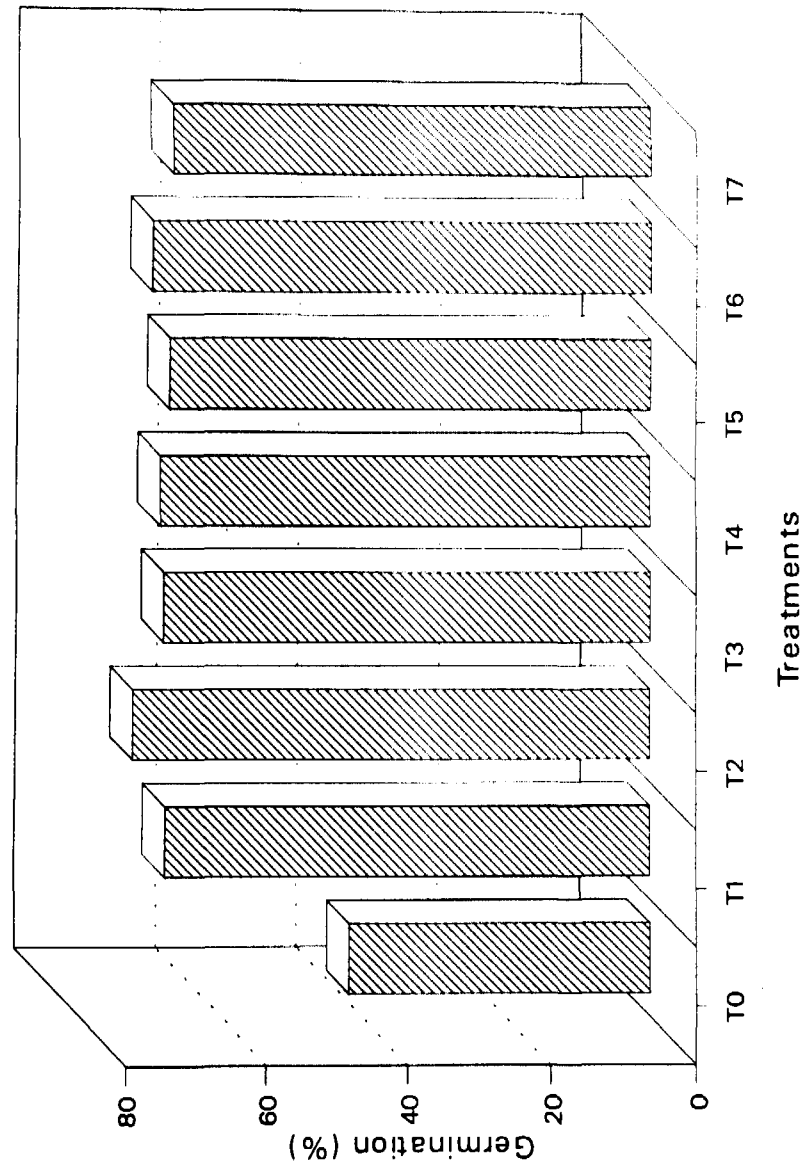


Fig. 12. Effect of combination of acid scarification and GA₃ soaking on germination



The results are in corroboration with the earlier findings. Sulphuric acid scarification for 40 min. was effective for tropical species such as *A. senegal* (Laurie, 1974), 60 min. for *Parkia javanica* (Sasaki, 1980) and *A. tortilis* (Doran *et al.*, 1983), 15 min. for *Leucaena leucocephala* (Babeley and Kandya, 1985), 40 min. for *Cassia occidentalis* (Xu and Gu, 1985) and 50 min. for *A. nilotica* and *Parkia biglandulosa* (Rajasingh, 1987).

Increased vigour with optimum duration of acid scarification was reported earlier by Kumar and Purkayastha (1972) in *Acacia farnesiana* and by Kaul and Manohar (1966) in *Acacia senegal*.

In the present study, sulphuric acid scarification gave better results in *A. lebbek* by softening of seed coat (Hartman and Kester, 1976) which permits water uptake and gas exchange (Watanabe, 1954; Brown and Booyesen, 1969; Shybiany and Rouhani, 1976; Clemens *et al.* 1977).

Gibberellins are known to play a major role in overcoming dormancy and increasing the germination percentage of seeds (Mayer and Mayber, 1975; Shepley, 1975; Ovcharov, 1977). Nagaveni and Srimathi (1980) and Utomo *et al.* (1990) reported hastening of germination in sandal due to 0.05% GA₃ soaking indicating the usefulness of GA₃ in breaking seed coat dormancy. This stimulatory effect might be due to its antagonistic effect on germination inhibition substances and synergistic effect in intensifying the rate of metabolism during germination (Ovcharov, 1969; Khan, 1977). GA₃ treatment brought a decrease in \hat{A} -amylase activity at the time of germination (Ananthapadmanabha *et al.*, 1986). The results of this study i.e., enhancement of germination of seeds soaked in GA₃ 200 ppm for 24 h after acid scarification corroborate the findings of Unnikrishnan and Rajeeve (1990) in teak, Singh and Murthy (1987) in

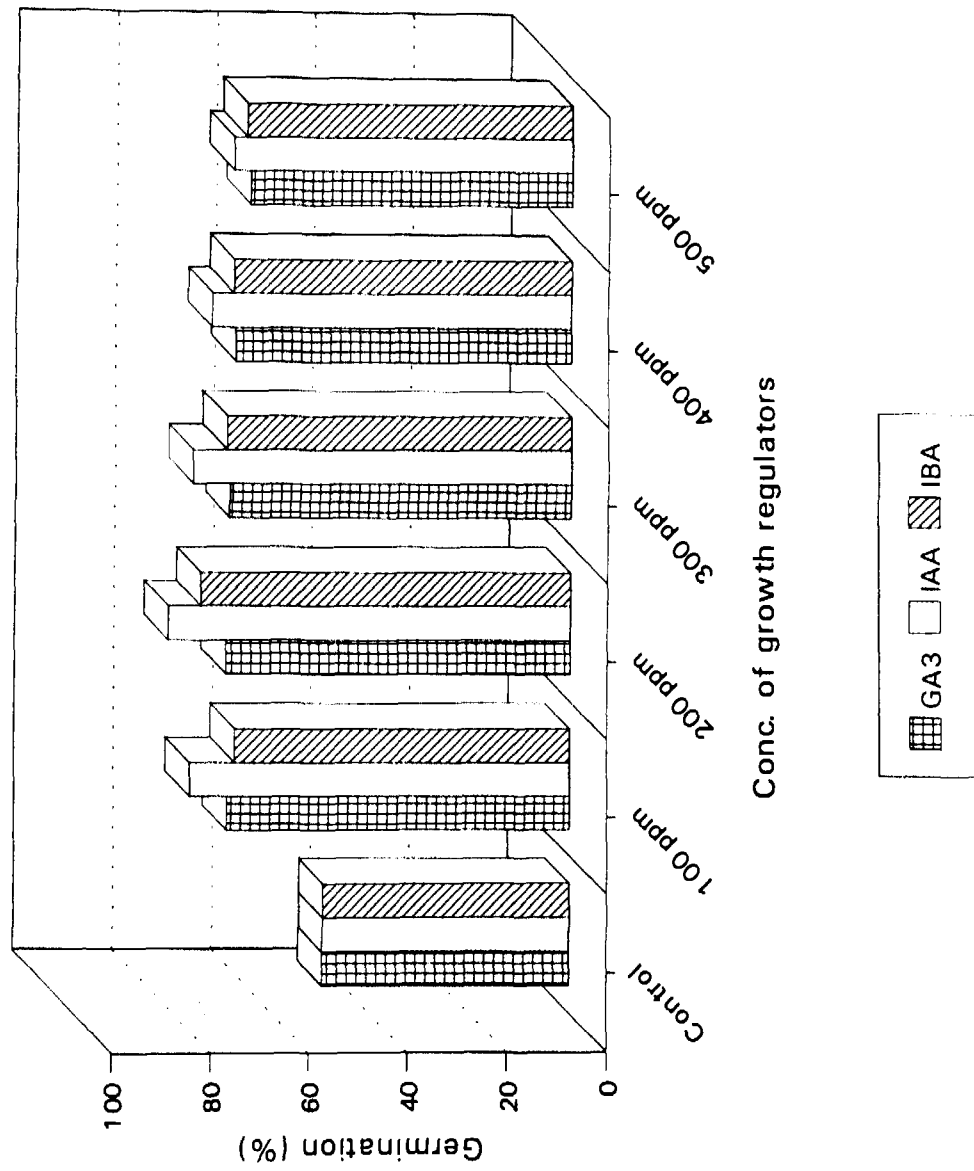
Cassia obtusifolia, Mukhopadhyay *et al.* (1990) in *Peltophorum ferrugineum*, Bhattacharya *et al.* (1991) in *Eucalyptus*, Kumaran *et al.* (1994) in neem and Manonmani (1997) in sandal.

In another study, twelve seed lots of *A. lebbek* were soaked in growth regulators viz., GA₃, IAA and IBA each at five levels viz., 100, 200, 300, 400 and 500 ppm. Statistically significant increase was observed due to growth regulators at different concentrations in germination and other parameters in all the seed lots. As far as germination was concerned, maximum increase of 38.9, 33.6 and 28.8 per cent was observed in IAA, IBA and GA₃ 200 ppm each, respectively (Fig. 13). With regard to root length, an increase of 28, 25.4 and 12.4 per cent was recorded over control in IAA 200 ppm, IBA 100 ppm and GA₃ 400 ppm, respectively. Shoot length showed an increase of 34 and 24.6 per cent over control at IAA 200 ppm and IBA 200 ppm, respectively. IAA and IBA each at 200 ppm concentration registered higher vigour index with an increase of 56.9 and 38.8 per cent, respectively over control. Whereas an increase of 31.2 per cent was observed in GA₃ 400 ppm compared to control. Maximum increase in drymatter production over control was recorded in IAA 200 ppm (34.0 per cent) followed by IBA 200 ppm (16.1 per cent) and GA₃ 200 ppm (7.0 per cent).

Hence, it is standardized from the above study that pretreatment with IAA 200 ppm is optimum for obtaining enhanced seed germination and vigour of the seedling.

Growth regulators stimulate and promote seed germination in a wide variety of tree crops (Khan, 1977; Webb and Wood, 1980; Verma and Tandon, 1988). Auxins are critical in germination because of their effect on cell elongation in *Thyrostachys siamensis* and *Dendrocalamus strictus* (Richa and Sharma, 1994). The promoting effect of auxins

Fig.13. Effect of growth regulators on germination of *A. lebbek*



on germination may be attributed to their indirect effect through change in membrane permeability, solubilization of carbohydrates through synthesis of different enzymes for promoting effects and production of some precursors needed for germination. The auxins may exert their primary effect on the cell wall and change subcellular proton concentration (Jann and Aman, 1977). The results are in line with the findings of with Virendra Singh (1990) in *Picea smithiana*, Gopikumar *et al.* (1991) in *Cassia fistula* and *Bauhinia purpurea*, Palani *et al.* (1996) in *A. lebbek*, Manonmani (1997) in teak and Venkatesh *et al.* (1997) in pungam. Sivagnanam (1995) in *Azadirachta indica* recorded increased germination due to IBA 100 ppm application. The increase in growth may be due to its strong promoting effect on elongation and growth of main axis, which perhaps result in rapid channeling of mineral nutrients and photosynthates towards apical meristem of the stem. Mishra and Mishra (1984) have showed that application of IAA increased the growth of root and shoot in *Tectona grandis*.

GA₃ controls the mobilization of starch which acts as a respiratory surface, as a raw material for synthesis of other growth regulators and increases the osmotic pressure of the cells leading to immediate enhancement in cell elongation (Nanda and Dhindsa, 1967). Several research reports endorse the enhancement of shoot by GA application (Verma and Tandon, 1988; Singh, 1989; Thapliyal, 1990; Bhattacharya *et al.*, 1991; Virendra Singh *et al.*, 1995; Masilamani and Dharmalingam, 1995; Gopikumar and Kunhamu, 1995; Venkatesh *et al.*, 1997b). Similar increase in germination was recorded due to auxin application in *Acacia nilotica* (Bhatnagar and Singh, 1981), *Dendrocalamus strictus* (Mishra and Mishra, 1984), *Tectona grandis* (Singh *et al.*, 1984) and *Madhuca latifolia* (Ananthapadmanabha *et al.*, 1986).

As an effort to augment and increase the germination potential of *A. lebbek* seeds apart from the soaking treatments, seed infusion was also resorted to. In the present study,

the seeds infused with GA₃ was found superior when compared to Kinetin and control (Fig. 14). The percentage of increase over control was 8.2 and over kinetin, it was 3.2. The percentage increases with respect to GA₃ application over control for root length, shoot length, vigour index and drymatter production were 13.8, 16.7, 22.2 and 35.8 respectively.

GA₃, kinetin, ABA, auxins, ethylene, vitamins and other regulatory substances are vitally important and their application to seeds intensify the metabolism and improve germination and plant productivity (Bonner, 1976; Mehanna *et al.*, 1985; Singh, 1985). The growth regulators may easily penetrate the seeds at their optimum concentration being available at the site of action (Bonner, 1976; Tinus, 1982).

5.3.3.2. Germination media

The suitable medium has to be standardized before recommending it for adoption. Medium play a significant role in germination, because seeds have characteristic requirements as to the amount of moisture and oxygen needed for germination. Substratum should be non toxic, free of moulds with adequate aeration and moisture for germinating seeds (Justice, 1972).

In the present study, germination medium was standardized with twelve seed lots of *A. lebbek*. The results of the experiment revealed significant differences in germination, seedling growth and vigour index when tested in different media of germination. Accordingly a maximum of 77 per cent germination was recorded in sand medium followed by roll towel medium (74.9 per cent). Whereas only 72.1 per cent was recorded when seeds were sown on top of the paper (Fig. 15).

Fig.14. Effect of seed infusion of GA₃ and Kinetin on germination of *A. lebbek*

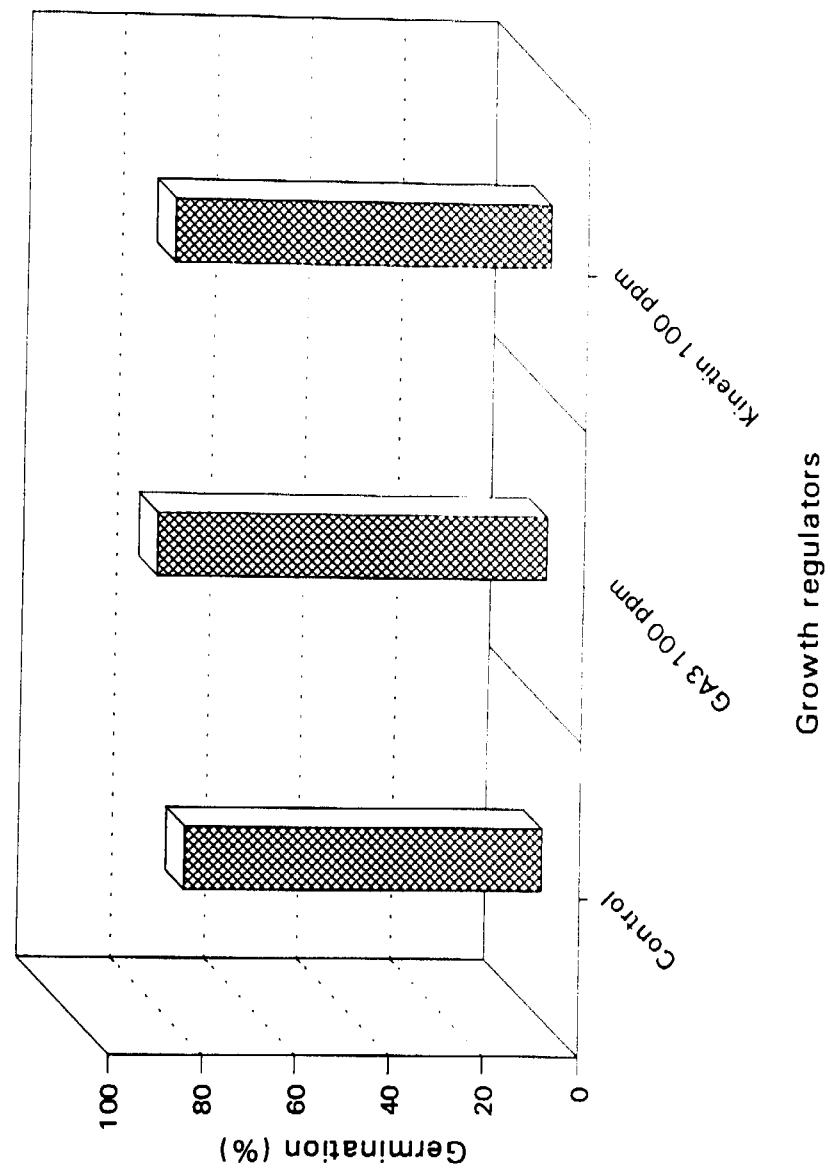
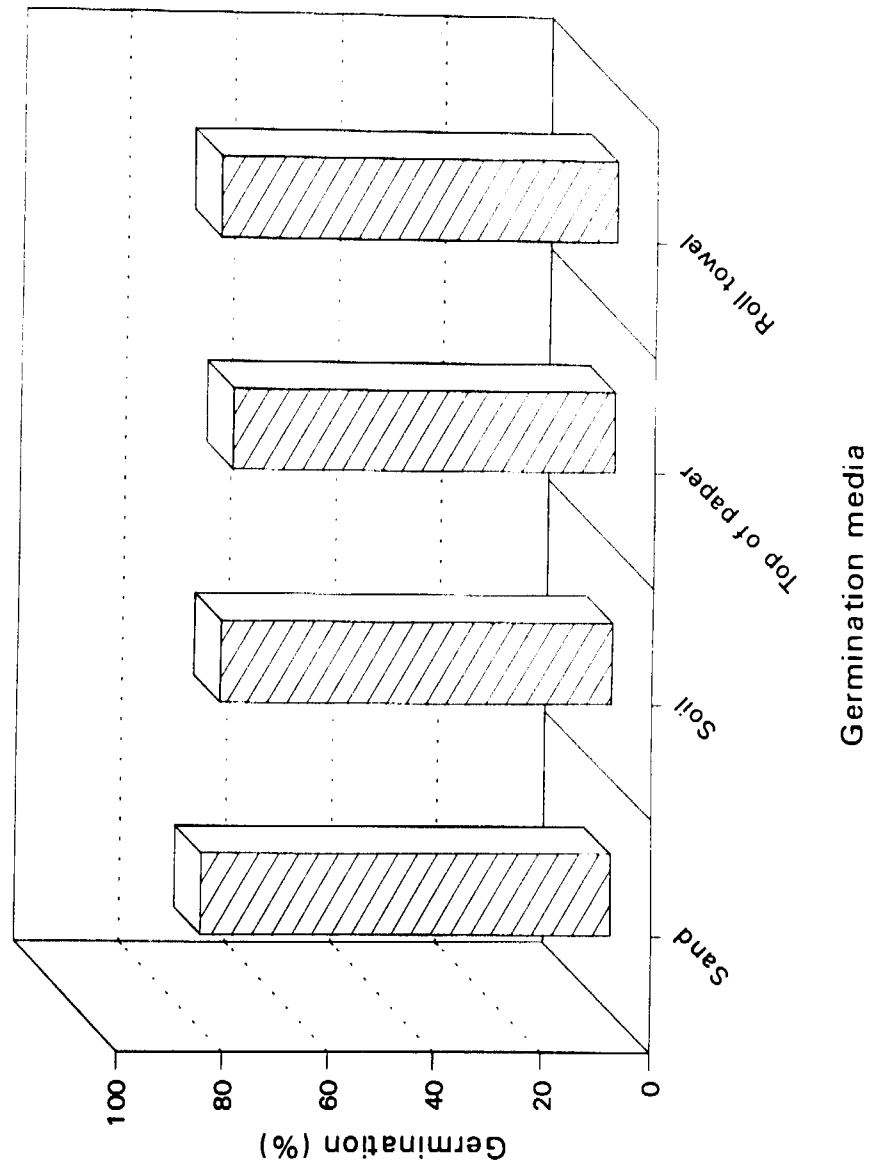


Fig.15. Influence of germination media on seed germination of *A. lebbek*



Maximum vigour index of 1836 was recorded in sand medium followed by soil (1798). Shoot length and drymatter production showed similar trend as that of germination. Therefore, it is recommended that sand medium should be prescribed for conducting germination test of *A. lebbek* seeds.

Sand as a germination substrate is preferred for tree species of larger seeds (Magini, 1962). ISTA (1993) recommended sand medium for *Tectona grandis*. Damage of seedlings due to fungi is always less in sand than on paper.

The results of this study are in line with the earlier findings of Rajasingh (1987) in *Acacia auriculiformis*, *A. holosericea*, *A. mellifera*, *A. nilotica* and *Prosopis juliflora*, Purohit and Jamaluddin (1993) in *Butea monosperma*, *Dendrocalamus strictus*, *Pongamia pinnata* and Vanangamudi *et al.* (1998) in *Albizia procera*.

5.3.4. Quick viability (Tetrazolium) test

The tetrazolium test is the accepted biochemical test which differentiates the living and dead tissues of a seed by the presence or absence of a red stain, known as formazon. The intensity of the stain and its distribution are the criteria used to evaluate the potential germination of the seed.

From the inception of use of tetrazolium chloride for viability testing by Lakon (1942), numerous workers have successfully used it for the topographic determination of seed viability (Gopal and Thapliyal, 1969; Mackay, 1972; Moore, 1973; Gupta and Raturi, 1975). Standard procedures for particular species have been worked out in various parts of the World (Agarwal *et al.*, 1973; Gopal and Thapliyal, 1969; Gupta and Raturi, 1975). A standardized procedure for *A. lebbek* is necessary as a reliable indication of viability. When an ISTA certificate has not been issued, the analyst is free to

choose a concentration suited for the purpose. In fact, the concentration of the solution is not conclusive for the practicability of the method and concentrations of 0.1% to 1.0% may be used successfully (Overaa, 1979).

The present investigation was carried out with twelve seed lots. Nipping off the seed coat followed by 12 h water soaking and longitudinal splitting of cotyledons (Plate 3) were standardized as the best suited preconditioning and preparation methods respectively for tetrazolium test. Among the two concentrations viz., 0.5% and 1.0% of the 2-3-5 triphenyl tetrazolium chloride, the viability percentage recorded differed significantly. The seeds recorded 82.3 and 83.2 per cent viability at 0.5 and 1.0%, respectively, which was decided based on the staining patterns (Plate 4&5). This indicates that 1.0% is optimum to test the viability percentage of the seeds through topographical tetrazolium test (Plate 6).

5.3.5. Vigour tests

In the present study statistically significant differences was obtained among the seed lots and the concentrations of NaCl solutions. Maximum reduction in germination percentage was obtained for all seed lots with 1.0% concentration. A similar result was obtained with 0.75% concentration for five seed lots viz., Coimbatore, Ramanathapuram, Madurai, Chinglepet and Trichy out of the nine seed lots. The trend of result did not match with 0.25 and 0.50% concentrations. Hence, 0.75% concentration of NaCl is recommended for testing the salinity or salt tolerance of the seeds.

From the results, it is evident that apart from the total salt concentration which exerts deleterious effect in increasing the mortality percentage, the higher proportion of sodium ion in relation to Ca + Mg also seems to play a toxic role in increasing the mortality percentage of the forest species (Tomer and Yadav, 1980). Hayward and

choose a concentration suited for the purpose. In fact, the concentration of the solution is not conclusive for the practicability of the method and concentrations of 0.1% to 1.0% may be used successfully (Overaa, 1979).

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5.3.5. Vigour tests

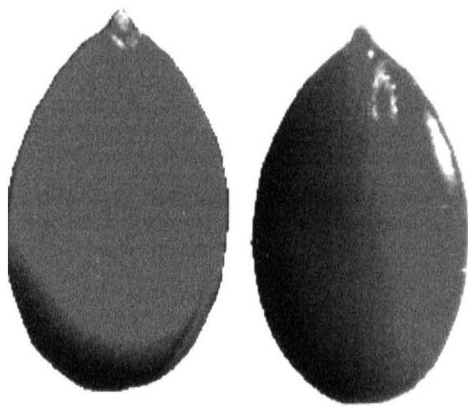
In the present study statistically significant differences was obtained among the seed lots and the concentrations of NaCl solutions. Maximum reduction in germination percentage was obtained for all seed lots with 1.0% concentration. A similar result was obtained with 0.75% concentration for five seed lots viz., Coimbatore, Ramanathapuram, Madurai, Chinglepet and Trichy out of the nine seed lots. The trend of result did not match with 0.25 and 0.50% concentrations. Hence, 0.75% concentration of NaCl is recommended for testing the salinity or salt tolerance of the seeds.

From the results, it is evident that apart from the total salt concentration which exerts deleterious effect in increasing the mortality percentage, the higher proportion of sodium ion in relation to Ca + Mg also seems to play a toxic role in increasing the mortality percentage of the forest species (Tomer and Yadav, 1980). Hayward and

Plate 3. Quick viability test – Preparation methods

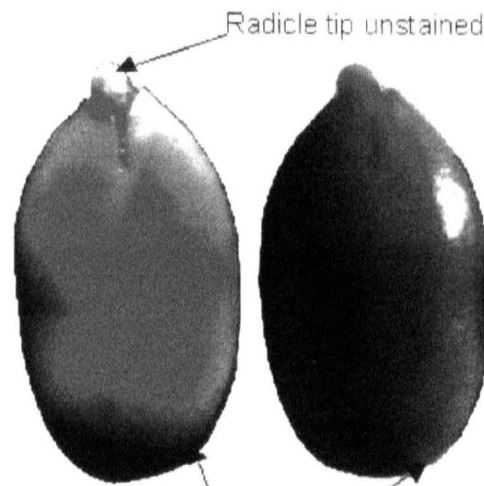
1. Complete removal of seed coat

Viable seed



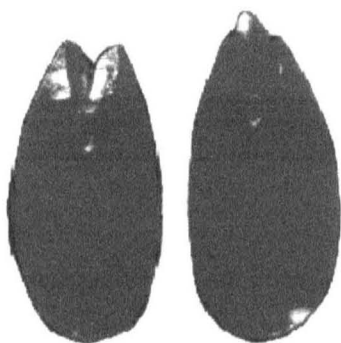
Embryo completely stained

Non-viable seed

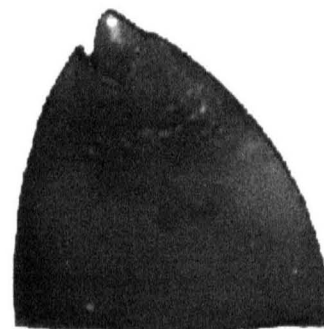


Cotyledon unstained

Radicle tip unstained



2. Longitudinal splitting of cotyledons



3. Transverse cut

Plate 4. Quick viability test – Staining pattern of seeds

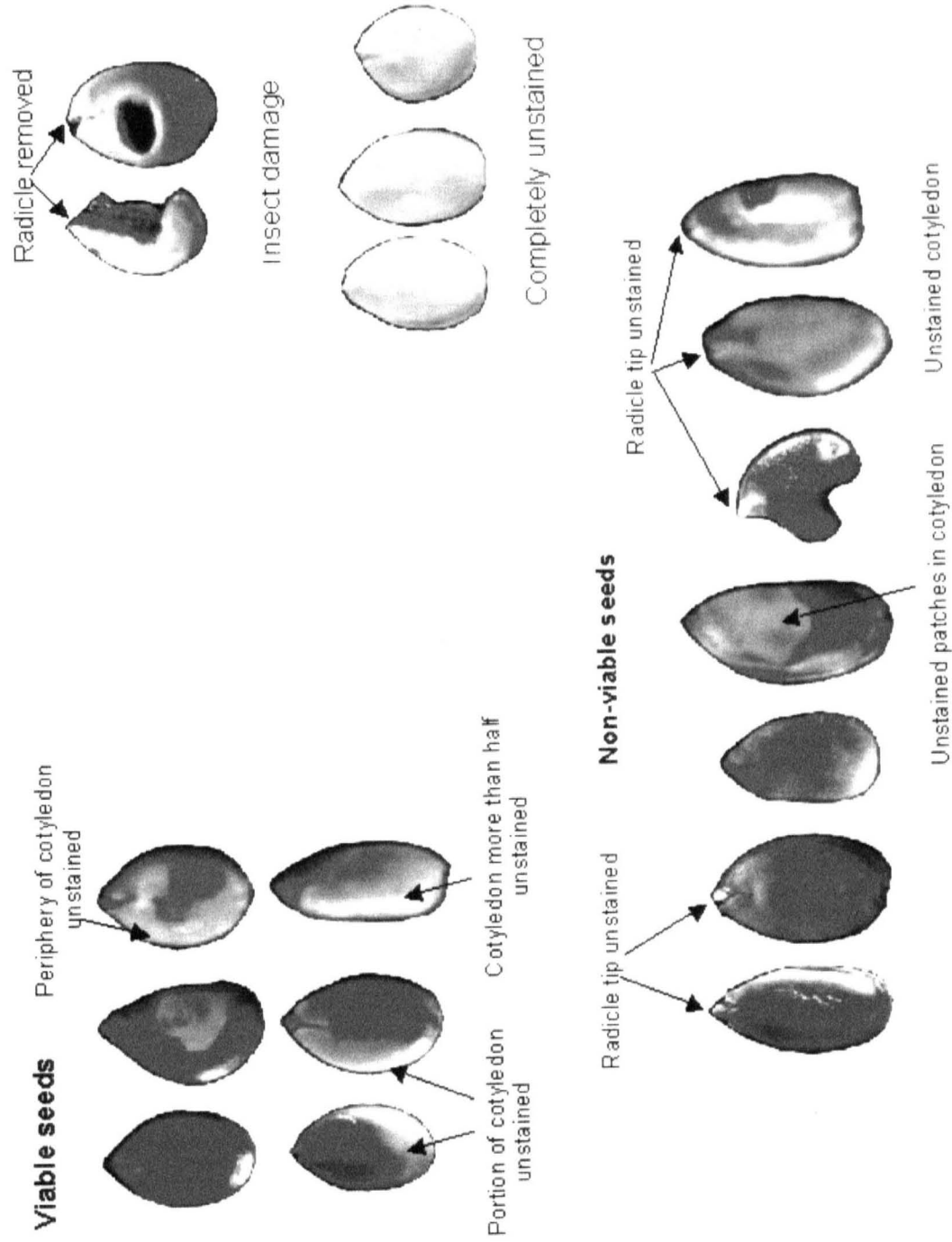


Plate 5. Quick viability test – Staining pattern of seeds

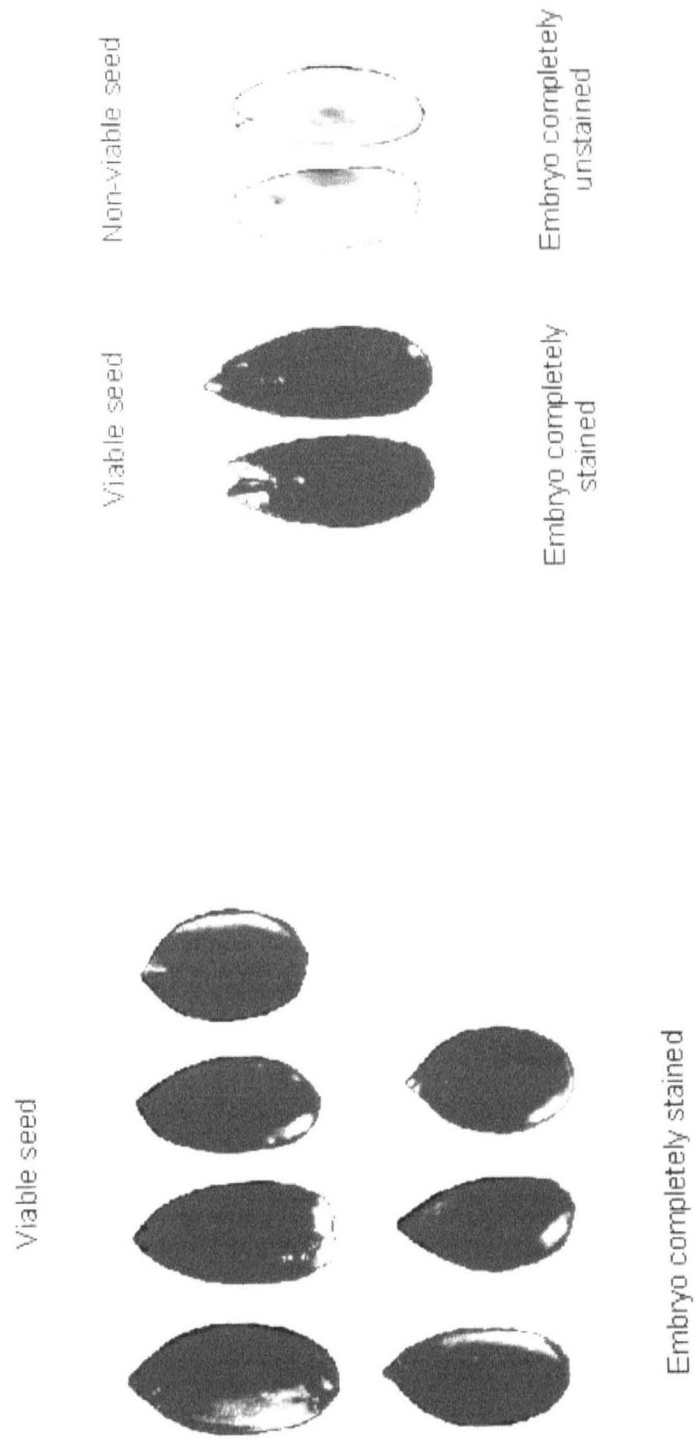
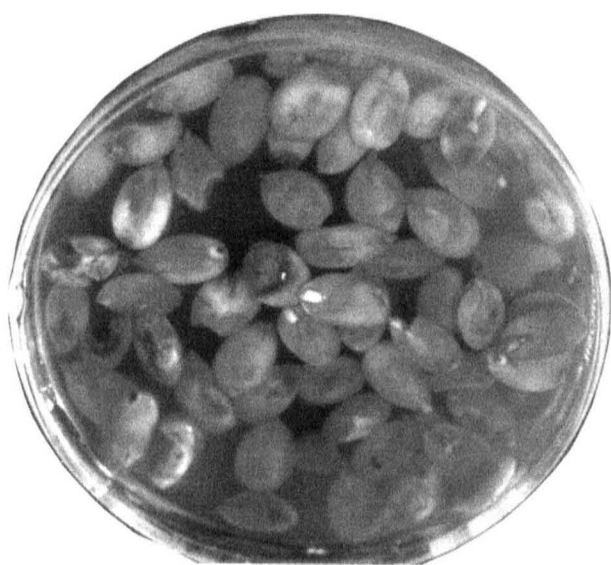


Plate 6. Comparison of staining pattern between 0.5 and 1% tetrazolium salt concentration



0.5



1%

the 8 DAA and 10 DAA. No such similarity was observed in the 2 and 4 DAA. Therefore, an accelerated aging test for 8 days is required to test the vigour of the seed lot.

Blanche *et al.* (1988) and Malta and Blanche (1989) reported that accelerated aging causes a decline in germination capacity of tree seeds, but the rate of decline varies with the species. The above results are in conformity with the observations made by Delouche and Baskin (1973) and with the results of Ramamoorthy and Karivaratharaju (1989) in tomato.

The various vigour test experiments revealed that 0.75% NaCl, pH 8, and 1.25% PEG are recommended for testing the tolerance of seeds towards salinity, alkalinity and drought condition. The accelerated aging for 8 days is recommended for estimating the vigour status of seed lot.

5.3.6. Seed health testing

Two media were consulted for seed health testing by involving twelve seed lots for *A. lebbek*. It was observed that the blotter medium was an effective medium compared to agar test, which exhibited maximum fungal content. The most commonly occurring fungi in both the medium were *Aspergillus flavus*, *A. niger*, *Penicillium* spp., *Mucor* spp. and *Alternaria* spp. Among the seed lots of *A. lebbek* Mettupalayam (16) followed by Madurai (27) recorded minimum fungal colonies. Whereas, Salem seed lot had shown a maximum of 221 fungi colonies followed by Chinglepet (127).

Screening of literatures revealed that in seeds of *Pinus*, *Cedrus*, *Dalbergia*, *Cassia* and *Eucalyptus citriodora* the seed borne fungi *Aspergillus* and *Penicillium* were prevalent (Munjal and Sharma, 1975; Mittal and Sharma, 1979, 1980, 1981, 1982). Presence of seed mycoflora was recorded in *Butea monosperma* (Purohit and Jamaluddin,

1993) *Celtis australis*, *Cassia siamea*, *Bauhinia variegata* and *Acacia cetechu* (Bharadwaj and Paul, 1995).

5.4. NURSERY TECHNOLOGIES

The efforts put forth to identify the CPTs to collect the best seeds of good physical, physiological and genetic qualities will be meaningful only if they are subjected to optimum nursery conditions and prepared best for the production of quality planting stock material. With this idea, experiments were carried out to standardize the optimum size of polybag container, root trainer, the best potting mixture and the best seedling grade for raising healthy and vigorous seedlings in the nursery.

Containers are increasingly used to improve outplanting survival and to minimize transplanting shock. Containers have many advantages i.e. quicker production, less disturbed root system, extension of planting season and easier planting site. Of late the root trainers have become familiarized for growing seedlings since they have the advantage of guiding the roots through projected ridges on the inner surface towards the open bottom end where they are air pruned.

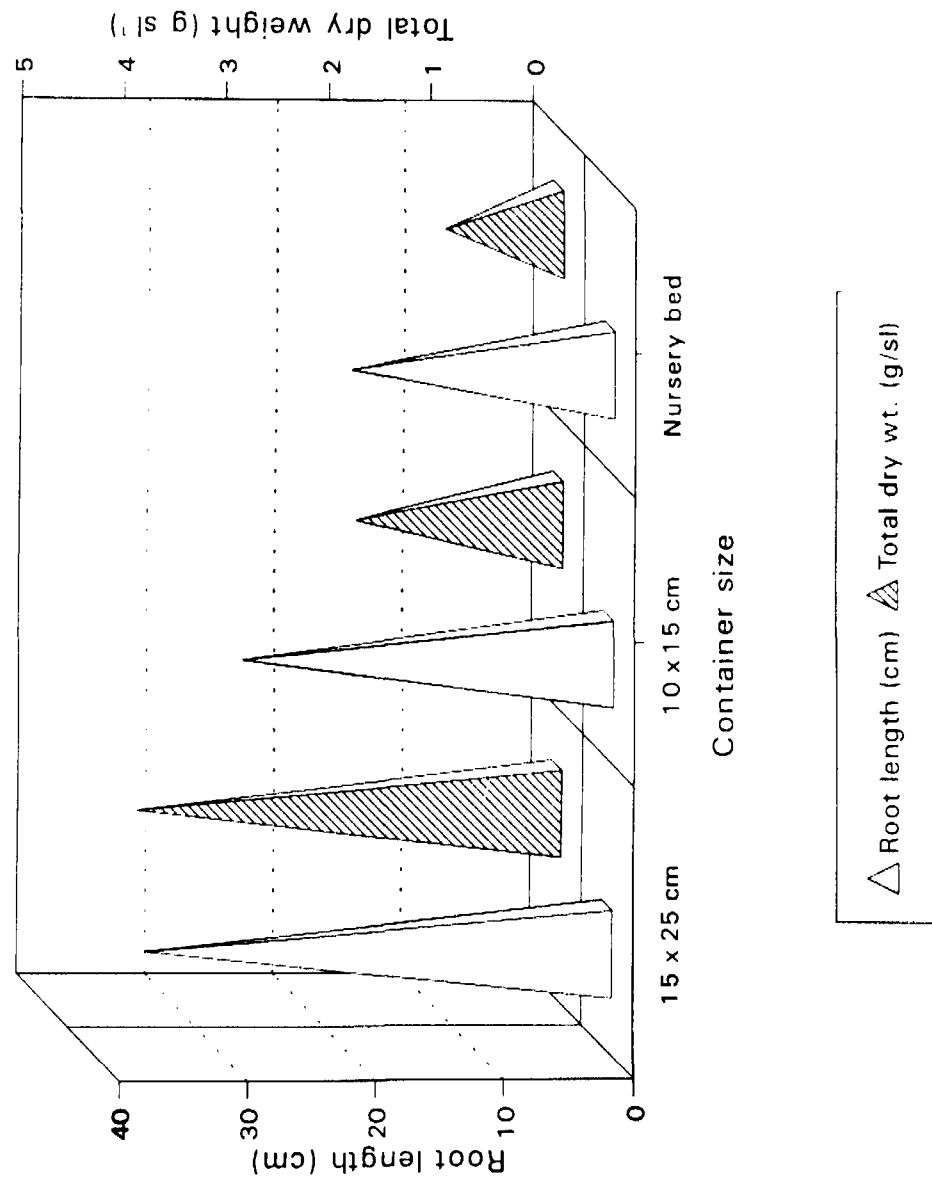
In the present study, the seedling morphometric parameters were superior in 15 x 25 polybags as observed during one, two and five months after sowing (Plate 7). At five months after sowing, the seedlings raised in 10x15cm and 15x25cm polybags registered 29.1 and 436.9 per cent increase for root length (Fig. 16), 31.3 and 52.7 for shoot length, 24.3 and 42.9 for shoot collar diameter and 43.7 and 73.0 for total dry weight, respectively over the seedlings raised in nursery bed.

The increased root length of container grown seedlings tend to perform better on adverse sites than do bare root seedlings (Goodwin, 1976) and they survive better under

Plate 7. Effect of container size on seedling growth



Fig.16. Effect of container size on root length and total dry weight of *A. lebbek* seedlings at 5 months after sowing

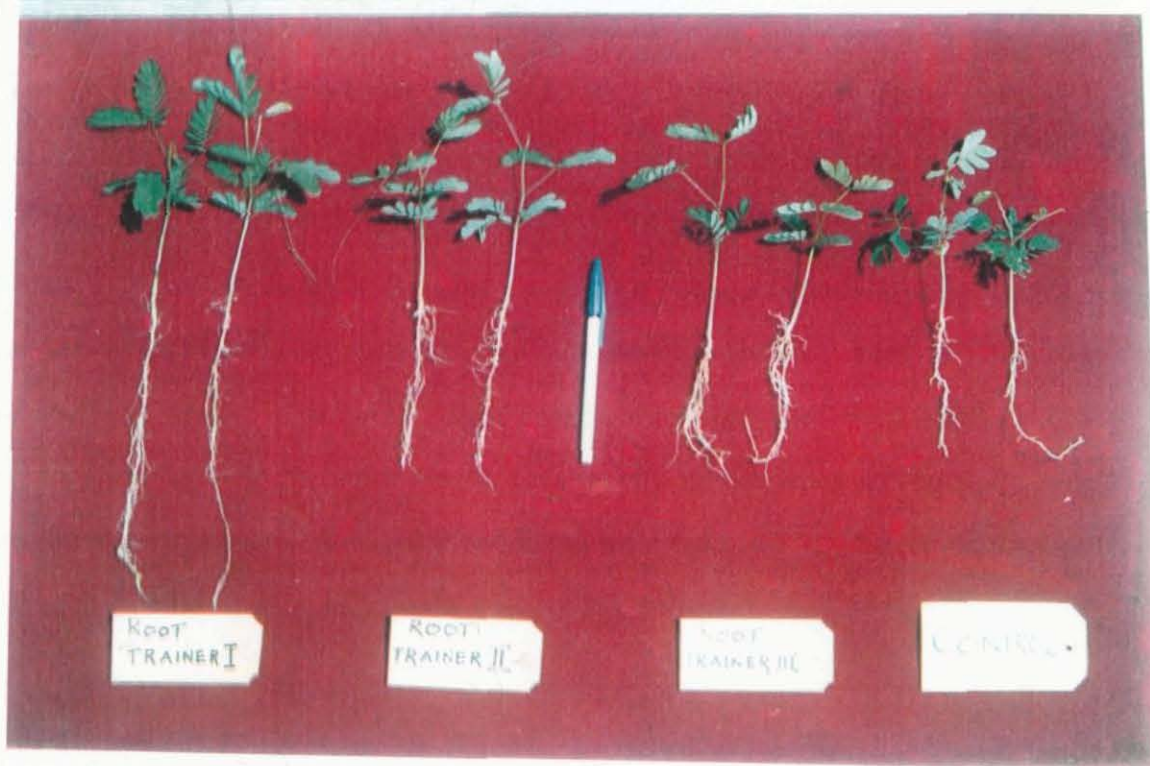
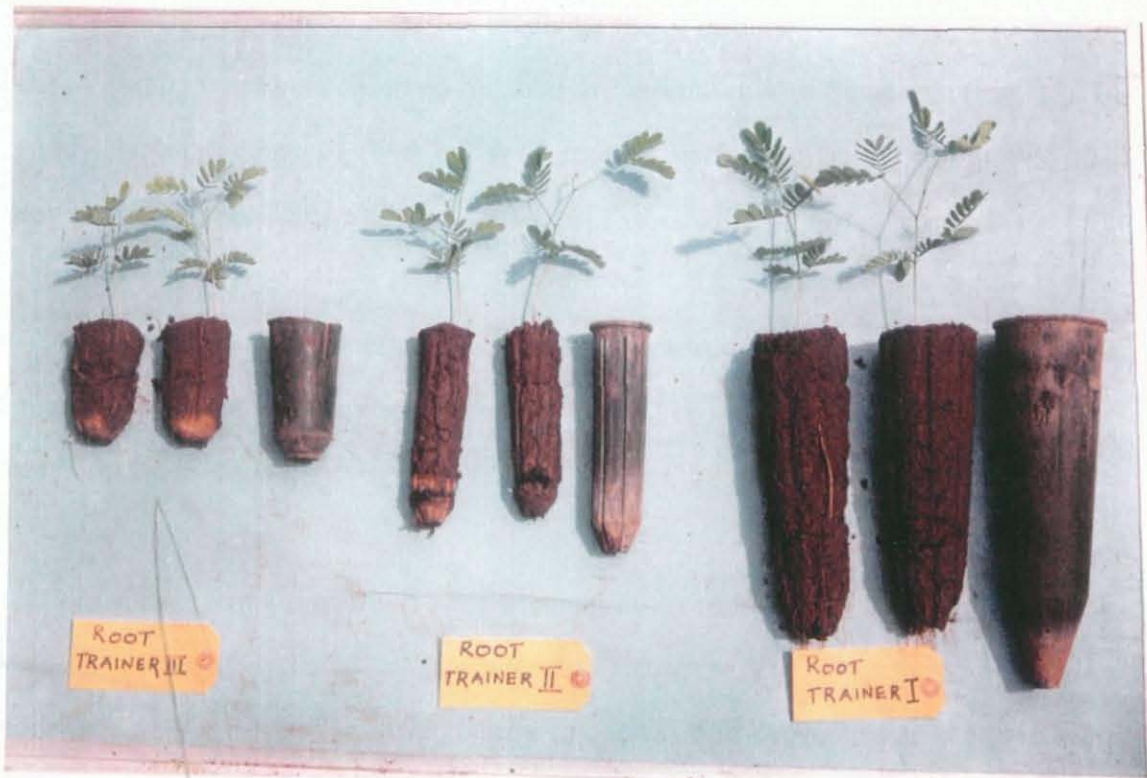


drought conditions (Amidon *et al.*, 1982). Milks *et al.* (1989) reported that plants growing in small containers have growth problems due to poor aeration or low water holding capacity of the growing medium. Aeration porosity is considered to be the most important physical property of any growing medium (Johnson, 1968; Bragg and Chambers, 1988).

In *Eucalyptus tereticornis*, the maximum seedling height was recorded in 25 x 25 cm size container than smaller containers (Jackson and Oja, 1970). Similarly the cocoa seedlings performed better in 30 x 20 cm polybag (Keshavachandran and Nair, 1985). *Acacia* seedlings grown in 25 x 13 cm gave better results than polybags of smaller dimensions (Natarajan and Jayaraj, 1986). *Albizia procera* performed better in 23 x 11 cm polybag (Mohit Gera, 1997).

In the present study, compared to seedlings raised in nursery bed the seedlings grown in 300 cc and 600 cc root trainers showed 22.5 and 54.3 per cent increase for root length. However, seedlings raised in 150 cc root trainers was on par with seedlings raised in nursery bed at one month after sowing. At three months after sowing, the seedlings raised in 150 cc, 300 cc and 600 cc root trainers registered 16.7, 42.0 and 62.2 per cent increase respectively, over seedlings raised in nursery bed for root length (Fig 17, Plate 8). Regarding shoot length, an increase of 15.2, 25.7 and 33.9 per cent were recorded in 150 cc, 300 cc and 600 cc respectively over seedlings raised in nursery bed at one month after sowing. During the evaluation at three months after sowing, it exhibited 5.2, 33.9 and 38.9 per cent increase, respectively (Plate 8). A similar trend was observed for number of leaves, shoot collar diameter and number of nodules at both the stages. Considering the root dry weight, a tune of 61.2, 62.1 and 65.6 per cent increases were recorded in 150 cc, 300 cc and 600 cc over the seedlings raised in nursery bed respectively, after one month of sowing. After three months after sowing, it was 78.0, 88.7 and 90.5 per cent respectively. In case of shoot dry weight, the seedlings grown in

Plate 8. Seedling growth as influenced by root trainers



150 cc, 300 cc and 600 cc root trainers registered 22.3, 25.1 and 52.2 per cent increase, respectively over seedlings raised in nursery bed at one month stage and it was 41.3, 71.5 and 77.1 per cent respectively over the seedlings raised in nursery bed after 3 months of sowing. A similar trend was observed for total dry weight at both the stages (Fig. 17). In this study, larger volume of (600 cc) root trainers performed better for growth and development of the seedlings.

Similar results were reported by Endean and Carlson (1975) in lodgepole, Carlson and Endean (1976) in white spruce, Alm *et al.* (1982) in jack pine, Barnett and Brissette (1986) in southern pines.

The ideal potting mixture to raise seedling needs to be light, but at the same time conesine in nature and should contain adequate nutrients. The components of potting mixture used vary considerably from country to country and depending on the species to be raised (Laurie, 1974).

In this investigation, the germination was more (66.0) in red soil : sand : goat manure potting mixture which was on par with red soil : sand : vermicompost (Fig. 18). It recorded a per cent increase of 34.6 and 33.0, respectively over red soil : sand : FYM. The seedlings grown in the potting mixture of red soil : sand : goat manure registered 6.5, 1.2, 34.6 and 2.0 per cent increase for shoot length, root length (Plate 9), vigour index and total dry weight respectively, over the seedlings grown in red soil : sand : FYM mixture. The seedlings grown in red soil : sand : sago waste recorded 35.0, 40.0, 24.8 and 65.8 per cent decrease for shoot length, root length, vigour index and total dry weight respectively compared to seedlings grown in red soil : sand : FYM. Hence, it is concluded that red soil : sand : goat manure is the best potting mixture for *A. lebbek*.

Plate 9. Influence of potting mixture on seedling growth



Fig.17. Influence of root trainers on root length and total dry weight of *A. lebbek* seedlings at 3 months after sowing

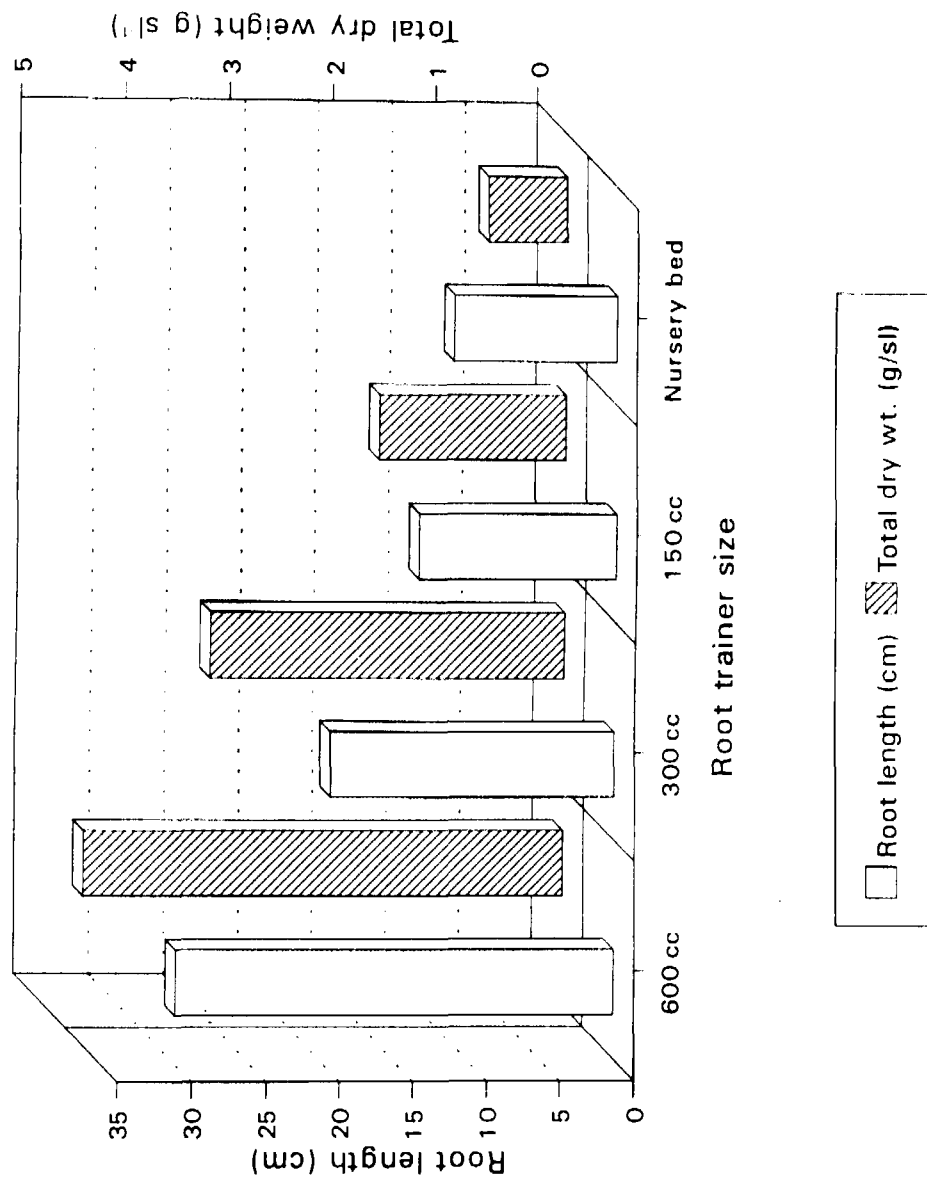
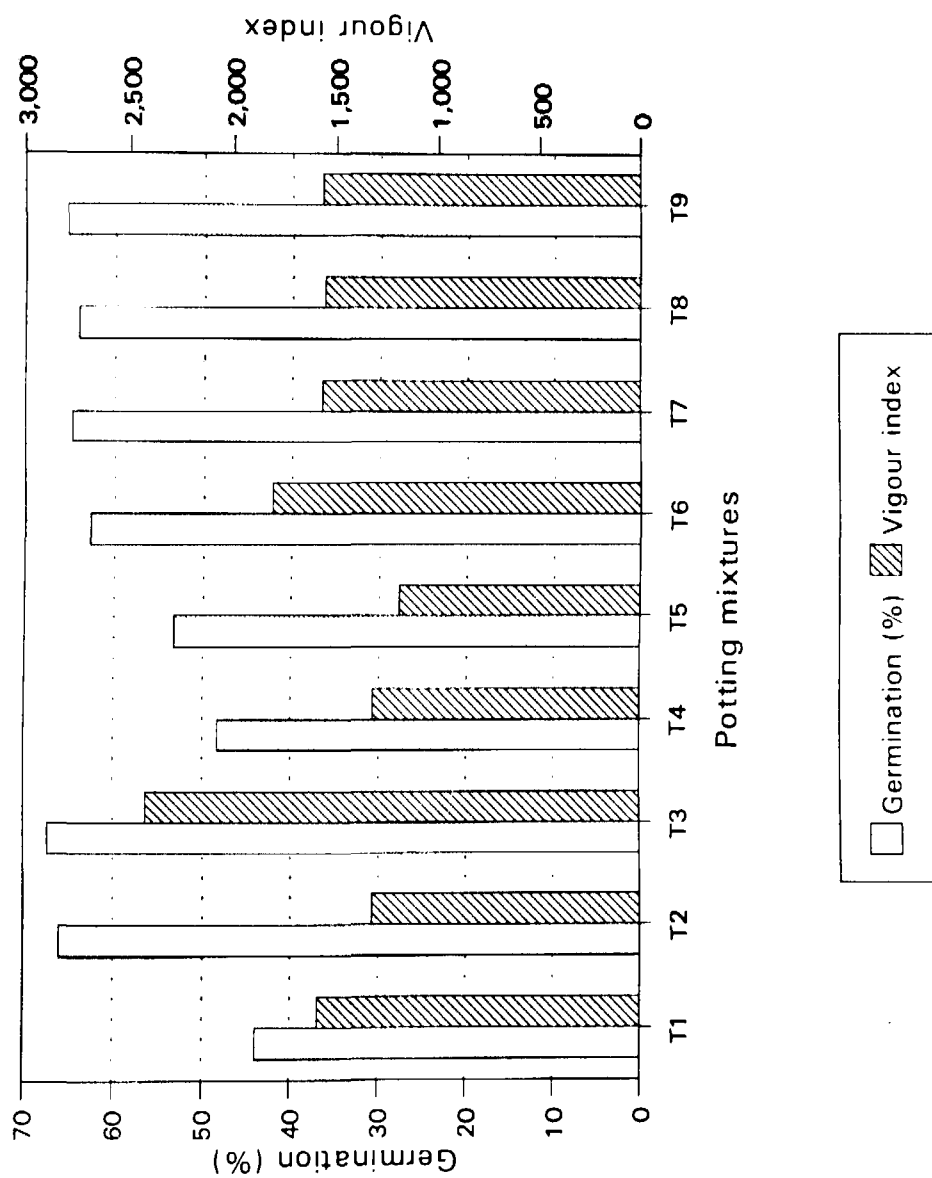


Fig.18. Effect of potting mixtures on germination and vigour index of *A. lebbek*



Root and shoot lengths were increased in *Eucalyptus tereticornis* under sand medium (Vinaya Rai *et al.*, 1980), in *Acacia* and in decomposed leaf compost loamy soil @ 1:4 ratio (Roy *et al.*, 1985).

Bohja Shetty (1977) suggested that red soil is best suited for *Eucalyptus* and some *Acacias*. Singh (1982) concluded that pulverized soil and coirpith in 2:1 ratio performed better for *Acacia* spp, *Leucaena leucocephala* and *Prosopis*.

The relative pore space of growing medium affect seedling growth and development in containers. A properly balanced pore space provide good gaseous exchange for the root system and directly affect water and mineral nutrients uptake (Dhiman and Sood, 1994).

To find out optimum height of seedlings for outplanting in the present study, the seedlings were graded into four height classes viz., 15-25 cm, 26-45 cm, 46-60 cm and 61-75 cm.

The seedlings that come under the height class of 61-75 cm (tallest grade) was found superior over the rest of classes during initial, one and three months after transplanting. The evaluation of seedlings at three months after transplanting revealed that seedling height classes viz., 26-45 cm, 46-60 cm and 61-75 cm recorded 33.3, 34.1 and 40.8 per cent increase for root length (Plate 10), 53.0, 58.4 and 64.4 for shoot length (Plate 10), 29.0, 53.0 and 58.5 for shoot collar diameter (Fig. 19), and 38.5, 60.4, 79.7 and 84.0 for total dry weight (Fig. 19), respectively over the seedling height class of 15-25 cm.

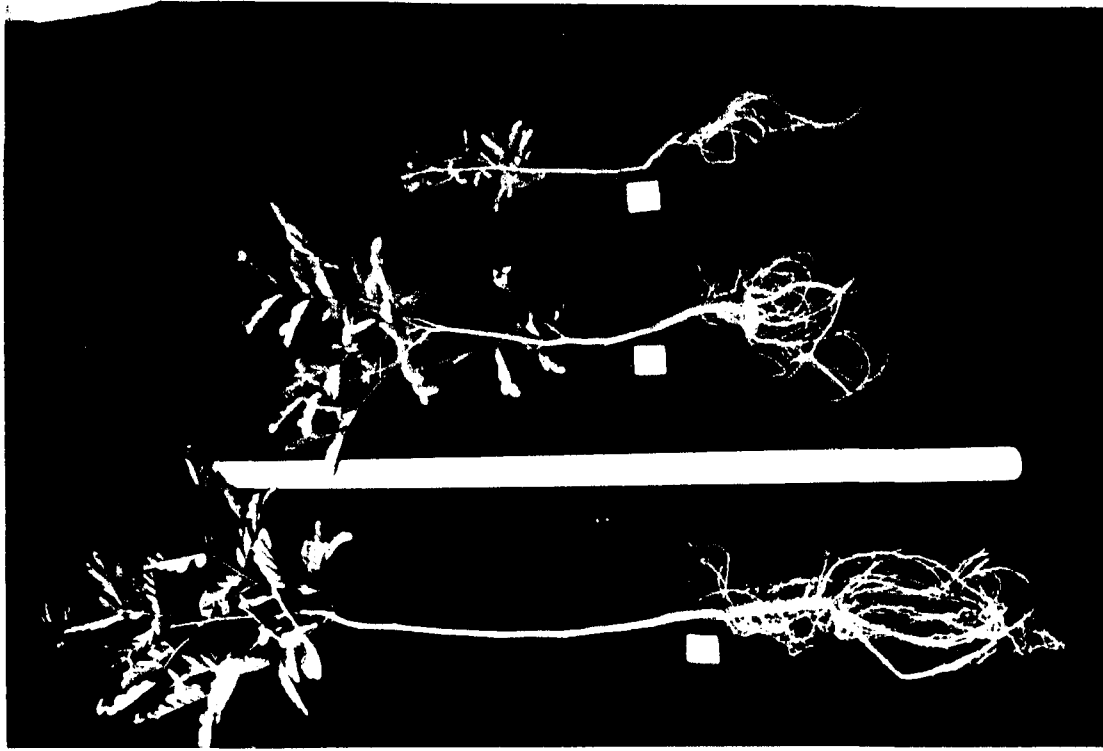


Plate 11 Effect of seedling diameter class on seedling growth

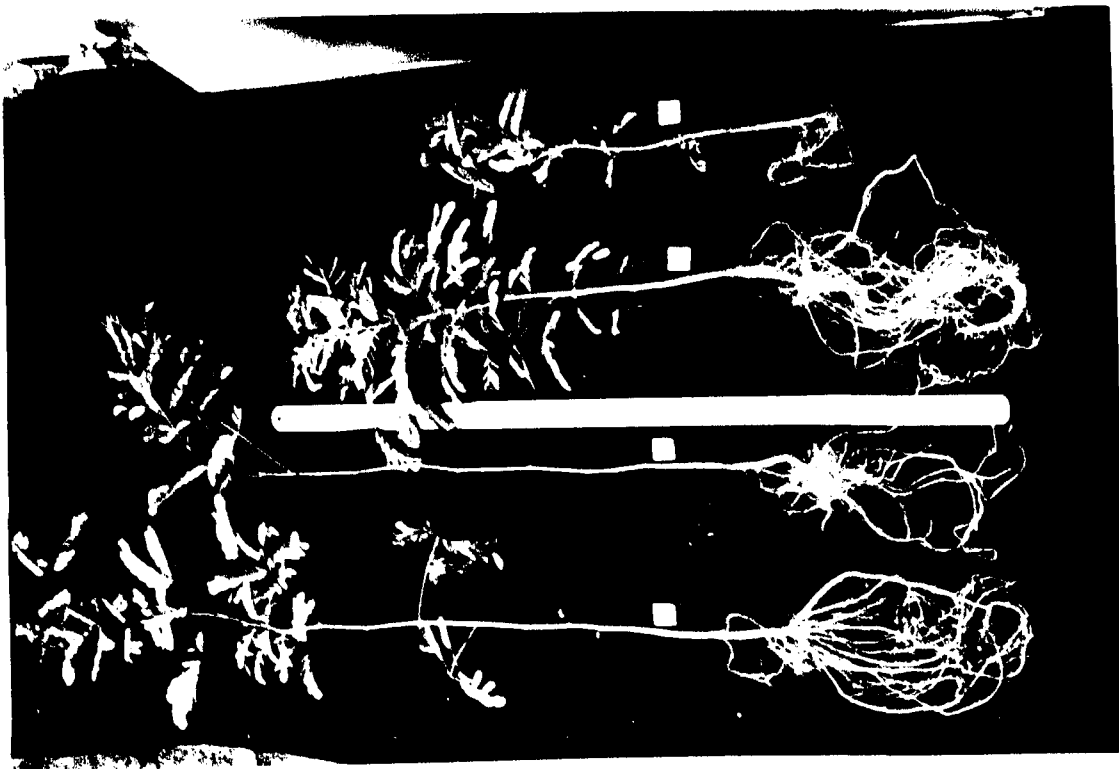
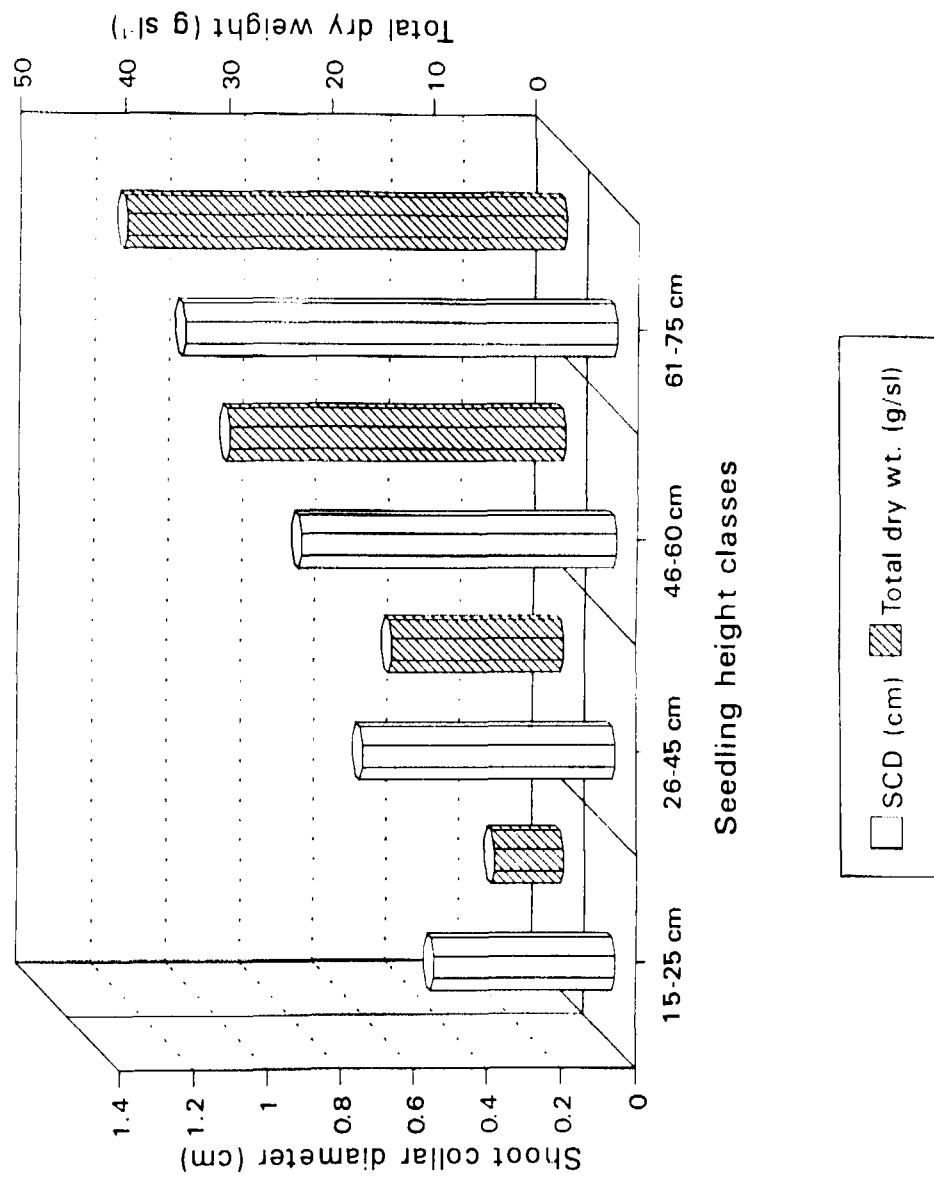


Plate 10 Effect of seedling height class on seedling growth

Fig. 19. Effect of seedling height class on shoot collar diameter and total dry weight of *A. lebbek* seedlings at 3 months after planting



It is concluded that selection of tall seedlings for field planting will produce trees capable of optimum survival with best resistance against death of the terminal shoot

Similar results of the best performance of higher height class was reported by Wakeley (1954), Minko (1974) and Singh *et al.* (1988) in spruce and Bhagat *et al.* (1990) in silver oak.

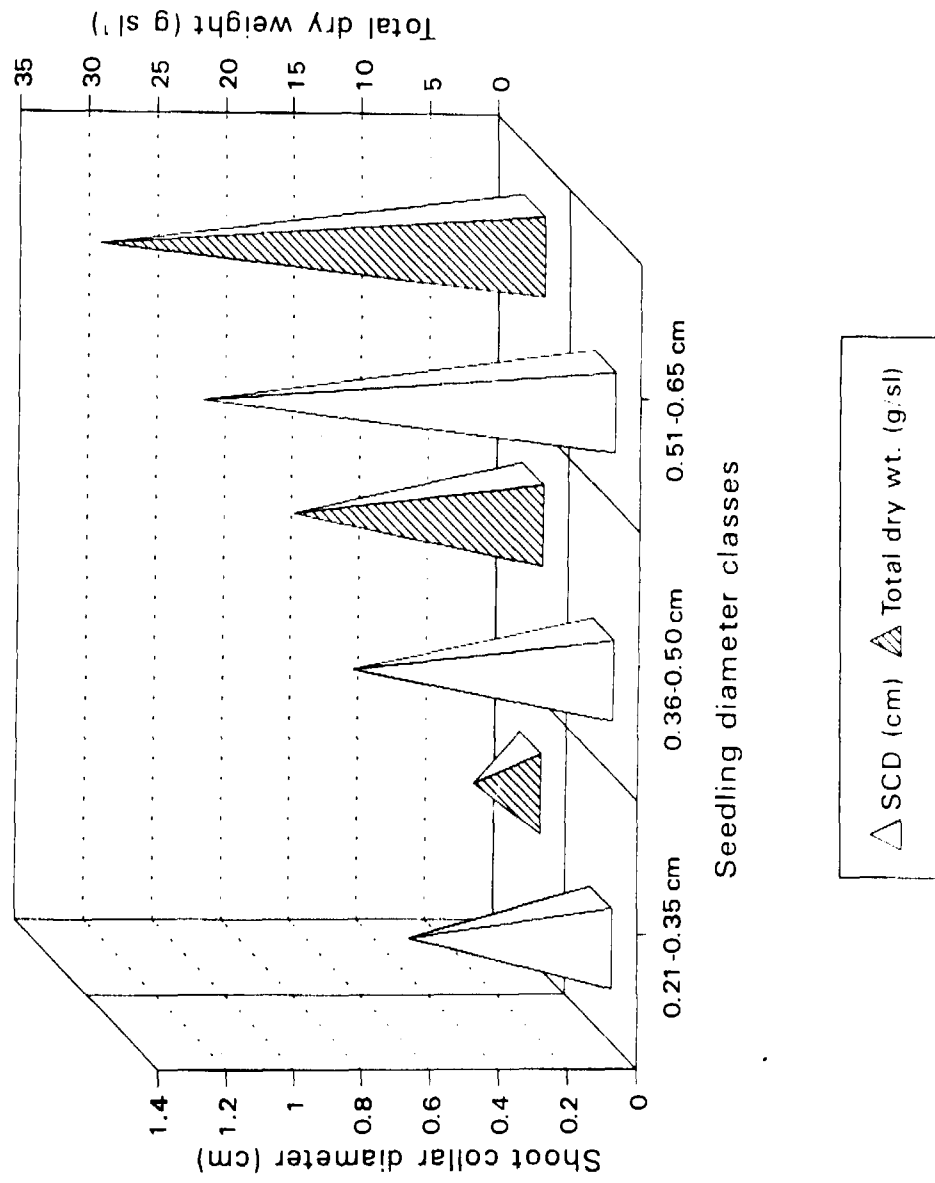
Venkatesh *et al.* (1997a) suggested in pungam that tallest seedling class of 51-60 cm height recorded the highest (94.2 per cent) survival and better seedling morphometric attributes than the other height classes.

The taller seedlings maintained their dominance over smaller ones. Grading of nursery stock would only be worthwhile where early height advantages would reduce competition for light and space or protect seedlings from animals (Minko, 1974). He also reported that mortality was the greatest with the smallest seedlings.

In the present study, the seedlings were also graded into three diameter classes viz., 0.21-0.35 cm, 0.36-0.50 cm and 0.51-0.61 cm to assess their performance in transplanting. The seedling growth parameters were superior in 0.51-0.65 cm diameter class than the 0.36-0.50 cm and 0.21-0.35 cm diameter classes as observed during initial, one and three months after transplanting. At three months after transplanting, the seedling diameter classes of 0.36-0.50 cm and 0.51-0.65 cm recorded 31.5 and 41.4 per cent increase for root length (Plate 11), 32.4 and 60.4 for shoot length (Plate 11), 23.3 and 52.5 for shoot collar diameter (Fig. 20), and 76.2 and 86.9 for total dry weight (Fig. 20), respectively over the seedling diameter class for 0.21-0.35 cm.



Fig.20. Effect of seedling diameter class on shoot collar diameter and total dry weight of *A. lebbek* seedlings at 3 months after planting



Hence, it is concluded that selection of seedlings with big diameter (0.51-0.65 cm) for field planting would produce trees capable of optimal survival.

The superior performance of bigger diameter class obtained in this study is in good agreement with the results of Lauer (1987) and Shiver *et al.* (1990) in *Pinus* spp. The seedlings with big diameter class with all good seedling attributes have the potential and capacity to withstand the adverse environmental and climatic conditions.

SUMMARY

CHAPTER VI

SUMMARY

Investigations were carried out in *Albizia lebbek* to identify the best seed source for the production of good quality seed, for standardization of seed testing procedures (sample size, purity analysis, pretreatments for breaking dormancy, germination medium, tetrazolium test, vigour test and seed health test) and development of nursery technologies for quality seedling production.

The seeds collected from the following seed sources Tirunelveli, Ramanathapuram, Madurai, Aruppukottai (Southern zone), Anamalai WLS, Aliyar, Coimbatore, Mettupalayam, Erode (Western zone), Salem (North Western zone), Chinglepet (North Eastern zone) and Trichy (Cauvery Delta zone) were studied in this investigation.

Among the twelve seed sources, Anamalai WLS and Coimbatore seed sources of western zone possessed superior CPTs based on their morphometric characters. A study on the evaluation of seed source for high quality seed production indicated that physical characteristics of seeds viz., seed breadth, individual and hundred seed weight were higher in Coimbatore (western zone) Madurai (Southern zone) and Chinglepet (North Eastern zone) for seed breadth and Ramanathapuram (Southern zone) and Trichy (Cauvery Delta zone) for individual seed weight and Anamalai WLS (Western zone) for hundred seed weight showed lower values. Seed thickness was more in Chinglepet and less in Salem (North Western zone) seed source.

The seed sources that belong to Southern (Tirunelveli) and Western (Anamalai WLS) agroclimatic zones recorded the highest germination of 94.0 and 91.0 per cent respectively. The root length, shoot length, shoot collar diameter, number of nodules and

total dry weight were high in Arupukottai, Madurai and Tirunelveli of Southern zone as well as Coimbatore and Aliyar of Western zone.

The Coimbatore, Mettupalayam, Aliyar and Erode seed sources belonging to Western zone outperformed in the field in terms of survival percentage and other growth parameters.

As far as NaCl salt stress condition was concerned, Coimbatore and Erode (Western zone) recorded the lowest percentage of decrease over control for germination. Trichy and Chinglepet showed the lowest tolerance to salt stress.

In pH study, Tirunelveli source (Southern zone) recorded the lowest percentage of reduction in germination, root length, drymatter production and vigour index at a pH of 10, over the control. This was followed by Coimbatore. The most affected source was Aliyar.

With respect to PEG test, the best source was Coimbatore which recorded the lowest percentage of decrease for germination, vigour index and total dry weight over the control at a concentration of 1.25%. Chinglepet recorded the least tolerance towards the stress imparted by PEG.

In case of accelerated aging, Ramanathapuram recorded the lowest percentage of decrease over control for germination after 10 days of accelerated aging followed by Anamalai WLS. The highest decrease over control was observed in Salem followed by Trichy. The lowest percentage of decrease over control for vigour index was observed in Ramanathapuram and Tirunelveli after 10 days of accelerated aging. Salem and Trichy registered the highest percentage of decrease.

The investigations on the standardization of seed testing procedures revealed that, the weight of 2500 seeds ranged from 232.430 to 338.110 g with an average of 276.150 g. Hence, it is inferred that the working sample size is 276 g. The weight of submitted sample is arrived as 2762 g, but subjected to a maximum of 1000 g as per ISTA rules. The weight of submitted sample is reported as 1000 g. The hundred seed weight ranged from 8.018 to 13.500 g, with an average of 10.776 g. In purity analysis, the pure seed fraction ranged from 98.3 to 99.6 per cent, with an average of 99.1 per cent. Hence, it is concluded that the seed lots of *A. lebbek* should possess a pure seed fraction of more than 99 per cent.

Studies on the identification of a suitable pre-treatment for breaking dormancy showed that the acid scarification for 25 min. is optimum for breaking dormancy and to produce more vigorous seedlings compared to pre-treatment with IAA 200 ppm for 24 h and GA₃ 100 ppm for 12 h.

In a study to standardize the suitable germination medium, high germination of 77.0 per cent was noticed in sand medium followed by roll towel medium (74.9 per cent). Whereas, only 72.1 per cent was recorded when seeds were sown on top of the paper.

The results of the quick viability (tetrazolium) test expressed that the nipping off the seed coat followed by 12 h water soaking and longitudinal splitting of cotyledons were standardized as the best suited preconditioning and preparation methods, respectively for tetrazolium test. A concentration of 1.0% 2,3,5 triphenyl tetrazolium chloride was optimum to test the viability of the seeds.

From the vigour tests, it is inferred that 0.75% concentration of NaCl could be recommended for salt stress test. pH of 8 was suitable to test the vigour of *A. lebbek*.

seeds towards alkalinity tolerance. The vigour of seed lots for drought resistance could be evaluated by treating the seeds in PEG at 1.25% concentration. For accelerated aging test, 8 days of aging was required to test the vigour of the seed lot.

Standardization of seed health testing showed that the blotter medium which exhibited maximum fungal infection was the effective medium compared to agar. The most commonly occurring fungi in both the media were *Aspergillus flavus*, *A. niger*, *Penicillium* spp., *Mucor* spp and *Alternaria* spp. Among the seed lots of *A. lebbek*, Mettupalayam followed by Madurai recorded minimum fungal colonies.

Nursery experiments conducted to develop a few technologies for high quality seedling production revealed the seedling morphometric parameters viz., root length, shoot length, shoot collar diameter and total dry weight were more in the seedlings grown in 15 x 25 cm polybag than 10 x 15 cm poly bag and control. The larger volume of (600 cc) root trainer produced vigorous and quality seedlings. The potting mixture containing red soil : sand : goat manure followed by red soil : sand : vermicompost gave higher germination and more vigorous seedlings. The seedlings which come under the height class of 61-75 cm (tallest grade) was found superior over 15-25 cm, 26-45 cm and 46-60 cm height classes. The biggest diameter class seedling (0.51-0.61 cm) outperformed other diameter classes.

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