# SELECTION AND EVALUATION OF SUPERIOR PLANTING MATERIALS OF *Ailanthus triphysa* (Dennst.) IN THRISSUR

By

**ABIJITH R**
**(2015-17-009)**

## THESIS

**Submitted in partial fulfillment of the requirement for the degree of**

# Master of Science in Forestry

**Faculty of Forestry**

**Kerala Agricultural University**


**DEPARTMENT OF SILVICULTURE AND AGROFORESTRY**
**COLLEGE OF FORESTRY**
**VELLANIKKARA, THRISSUR – 680 656**
**KERALA, INDIA**
**2018**

## DECLARATION

I hereby declare that the thesis entitled "**SELECTION AND EVALUATION OF SUPERIOR PLANTING MATERIALS OF *Ailanthus triphysa* (Dennst.) IN THRISSUR**"is a bonafide record of research done by me during the course of research and that this thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

ABIJITH R

Place: Vellanikkara

Date: 27/03/2018

(2015-17-009)

# CERTIFICATE

Certified that the thesis, entitled "**SELECTION AND EVALUATION OF SUPERIOR PLANTING MATERIALS OF *Ailanthus triphysa* (Dennst.)IN THRISSUR**" is a record of research work done independently by **Mr. Abijith R (2015-17-009)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Vellanikkara
Date: 27-03-2018

**Dr. V. Jamaludheen**
(Major Advisor, Advisory Committee)
Professor
Department of Silviculture and Agroforestry
College of Forestry
Kerala Agricultural University
Vellanikkara

# CERTIFICATE

We the undersigned members of the advisory Committee of **Mr. Abijith R (2015-17-009)** a candidate for the degree of **Master of Science in Forestry** agree that thesis entitled "**SELECTION AND EVALUATION OF SUPERIOR PLANTING MATERIALS OF *Ailanthus triphysa* (Dennst.) IN THRISSUR**" may be submitted by **Mr. Abijith R (2015-17-009)**, in partial fulfillment of the requirement for the degree.

27/03/2018

**Dr. V. Jamaludheen**
(Chairman, Advisory committee)
Professor
Dept. of Silviculture and Agroforestry
College of Forestry, Vellanikkara, Thrissur

**Dr. T.K. Kunhamu**
(Member, Advisory committee)
Professor and Head
Dept. of Silviculture and Agroforestry
College of Forestry, Vellanikkara, Thrissur

**Dr. E.V. Anoop**
(Member, Advisory committee)
Professor and Head
Dept. of Wood science and Technology
College of Forestry, Vellanikkara, Thrissur

**Dr. A. V. Santhosh Kumar**
(Member, Advisory committee)
Professor and Head
Dept. of Tree Physiology and Breeding
College of Forestry, Vellanikkara, Thrissur

**Dr. C.M. Jijeesh**
(Member, Advisory committee)
Assistant Professor
Dept. of Silviculture and Agroforestry
College of Forestry, Vellanikkara, Thrissur

R.C. Pandalai
27/3/18

**EXTERNAL EXAMINER**

# *ACKNOWLEDGEMENT*

*I express my It is with utmost respect and great devotion, I place on record my deep sense of gratitude and indebtedness to my major advisor* ***Dr. V. Jamaludheen,*** *Professor, Department of Silviculture and Agroforestry, College of Forestry for his constant inspiration and evaluation without which this endeavor would not have been fruitful. I also thank for his sustained and valuable guidance, constructive suggestion, unfailing patience, friendly approach, constant support and encouragement during the conduct of this research work and preparation of thesis. I consider myself being fortunate in having the privilege of being guided by him. I express my heartfelt and sincere thanks to him.*

*I owe my sincere thanks to* ***Dr. K. Vidyasagaran****, Dean, College of Forestry for his valuable advice and suggestions and constant help throughout the study period. I express my deep sense of gratitude to* ***Kerala Agricultural University*** *for the financial and technical support for pursuance of my research.*

*I take this opportunity to extend my unreserved thanks to* ***Dr. T.K. Kunhamu****, Professor and Head, Department of Silviculture and Agroforestry, College of Forestry, and member of my advisory committee for his constructive suggestions, constant encouragement throughout the study period. I express my heartfelt thanks to* ***Dr. C.M. Jijeesh****, Assistant Professor, Department of Silviculture and Agroforestry, College of Forestry and member of my advisory committee for his valuable help and suggestions during the course of this study.*

*I deeply indebted to* ***Dr. A.V. Santhosh Kumar,*** *professor and head, Department of Tree physiology and Breeding. College of Forestry, and member of my advisory committee for his imperative suggestions, timely help during the course of my study.*

*I express my gratitude to* ***Dr. E.V. Anoop,*** *Professor and head, Department of Wood science and Technology, College of Forestry, and member of my*

*advisory committee for his valuable suggestions and guidance during my research work.*

*I am thankful to* ***Mr. Jaslam****, Former, Teaching Assistant, Statistics, Department of Wildlife Sciences, College of Forestry, for his invaluable guidance for the statistical analysis of my study.*

*I would always like to remember the help offered by* ***Mr. Sajeev,*** *Farm officer, college of forestry, for his technical help and timely suggestions during the nursery and field experiments. I have infinite pleasure to express whole hearted thanks to AICRP on Agroforestry, College of Forestry, and the whole staffs for providing all the facility for the completion of my research work.*

*With all regards I sincerely acknowledge the generous help rendered my dear friends* ***Mr. Kiran. Mohan, Mr. Rahees. N, Mr. Sathyabrata. Nayak, Mr. Ajai. Sanker, Mr. Sreekumar. E. R, Mr. Suresh. Ramanan, Ms. Jeesma. V.J,*** *and my juniors* ***Ms. Rose Mary, Ms. Acsah, Mr. Eldhose,*** *and* ***2014****,* ***2015*** *and* ***2016*** *UG batch and my seniors for their immense help and support for my research work is remembered with gratitude.*

*I am forever beholden to my parents and family for their unfathomable love, boundless affection, personal sacrifice, incessant inspiration, and constant prayers which gave me strength to get through all tedious circumstances.*

*I humbly bow my head before the* ***Lord Almighty*** *who bestowed on me the confidence and will power to complete this endeavor successfully.*

ABIJITH.R

# CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF PLATES

# INTRODUCTION

# INTRODUCTION

Tree planting efforts in India has been largely limited to free and indiscriminate distribution of large number of seedlings in bulk without due consideration of needs, priorities and attitudes of the intended target group. As in the case of agriculture, the interest shown by a farmer for raising tree crops in his land are mainly influenced by the sociological, economic, demographic and environmental factors. These factors influence the choice of a farmer for the "adoption of a new technology" and this is especially so in a subsistence farming system, which is a typical farm scenario in Kerala (Nair and Sreedharan, 1986; Jose, 1992). Kerala farmers prefer timber trees such as teak and ailanthus besides fruit trees such as mango, jack, and cashew (Kumar, 2000). People are more interested in cultivating forest trees not only for conservation aspects but as a source of their income.

In this context, *Ailanthus triphysa* is a promising tree species used for various end uses. The tree will attain a height of 30 m and diameter of 1.2 m with cylindrical bole. It is a fast growing species that attains a merchantable volume at the age of 6 – 8 years. The tree is propagated through seed. Because of its fast growing nature *Ailanthus triphysa* is a good source of income for farmers. The farmers are interested in cultivation of *A. triphysa*, because of its fast growth, minimal space utilization, ready market and generous revenue. The demand of this wood increased exponentially but the area under plantations is very less as compared to other commercial timber species. The state of Kerala have 144 match factories, they can meet only about 10 per cent of total market demand from the state (Nair and Sreedharan, 1986). Expanding yield of plantations by genetic improvement techniques is a possible option to meet the rising raw material requirement of the industry. In this back ground, the present study is undertaken for selection and

evaluation of superior planting materials of *Ailanthus triphysa* and also to assess the initial growth performance of seedlings planted in the field.

The present study examined germination parameters such as germination percentage, mean daily germination, germination value and peak value of germination and the nursery performance evaluation on seedling height, collar diameter, number of leaves, number of leaflets, taproot length, number of secondary roots, number of tertiary roots, fresh and dry weight of shoot and root and root-shoot- length ratio. Again, these candidate plus tree selections were evaluated in the field for a period of six months. The improvement of this tree species can be achieved through systematic and careful selection of the mother plant and its propagation.

People are more interested in cultivating forest trees not only for conservation aspects but as a major part of their income. Hence, this study mainly focused on selecting the plus trees for propagation and production of superior quality seedlings by selecting seeds from phenotypically superior trees. The assessment of initial field performance also thrown light into the advantages of early stand development and the possible reduction of the rotation year planned for *Ailanthus triphysa* with the following objectives.

- Seed collection, selection and evaluation of superior planting materials of *Ailanthus triphysa.*
- To assess the initial growth performance of seedlings planted in the field.

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

## 2.1 PLUS TREE SELECTION

Silviculture has been widely accepted all over the world to enhance social and economic gains from the forests. For getting better returns from the forest, we need to use the best planting materials. These vigorous and healthy planting stock will respond well to management, and produce high-quality raw material in a short time. Tree breeding is the most suitable method for getting this achievement. Selection of "superior" or "plus "trees shows good response in the tree improvement programmes, so this method is widely used by silviculturists as well as geneticists.

Plus trees are mainly used for the formation of clonal and/or seedling seed orchards, for selective breeding programmes and hybridization. The superiority of the plus trees can be determined by proper progeny trials. The selection of the plus trees are based on growth rate, timber form, freedom from diseases and insects, yield, individual-tree height, stem diameter or volume is generally the highest priority trait in plus-tree selection (Zobel and Talbert, 1984). It is one of the common method for producing superior genotypes. The selection is not only based on selection intensity, but also on the genetic and environmental parameters of the population (Longman and Jenik, 1987). Selection is based on the principle that the average genetic value of selected families would be better than the average of families in the base population (Zobel and Talbert, 1984). The selected superior progeny will always show better performance than controls. In unfavourable conditions, gain may become zero. The Plus tree selection executed based on genetic principles but, an efficient selection is done by a general plan of the program (Morgenstern *et al.*, 1975). Phenotypic correlation is another method of evaluation of characters, while the genotype and environment has greater influence of these traits. The genetic correlation is attained

by neglecting environmental influence, as in a proper analysis of progenies from open-pollinated or control-pollinated parents, and the progenies should be replicated on several sites (Becker, 1967). The variations in a tree improvement programme fluctuate with different levels such as species, within trees, differences between trees within families, differences between families within provenances, geographic (provenance) variation, and variation among sites within provenance levels (Zobel and Talbert, 1984). The quantitative traits such as height and diameter of trees, yield from the trees, differ in degree. According to Falconer (1960) genes and environment have small influence on phenotypic expression, for study of inheritance of qualitative traits by the measurement of genetic variances and populations. The trees from the first generation seed orchards have 7-1 per cent more volume per hectare than trees from wild stand during harvesting. The genetic variability has less influence of the population sustainability while for a long period of time it has a great role in population sustainability (Lande and Shannon, 1996).

## 2.2 SEED SOURCE EVALUATION

Selection of proper seed source of a species for a given region is mandatory for maximal productivity both in plantation forestry, and agroforestry systems. Examination of naturally existing variability aid the tree breeder for achieving fast genetic improvement. Forest species with huge heterozygosity also show ample variation in characters such as pod size, morphology of seed traits, hard seed coat, dormancy, pre-treatment essentials, stratification span, germination rate and cardinal temperature for storage and optimum germination. Knowledge on variations within seed zones will support to suggest future breeding program (Willan, 1985). The implication of source alteration in seed and seedling characters has been examined in certain of tree species, *Acacia catechu* (Ramachandra, 1996), *Acacia mangium* (Salazar, 1989). Once trees are examined systematically for differences in easily recognizable traits, a great deal of variation can be found (Morgenstern *et al.*, 1975).

Spatial structuring of genetic differences is common in most plant species throughout their range. Seeds of good genetic potential are needed for maximising adaptability and yield potentials (Goel and Behl, 2001). Seeds collected from open-pollinated plus trees were germinated and were established in plantations for seed production. A few seedling seed orchards have been planted with the intention of combining progeny testing with seed production (Wright *et al.*, 1995), but due to the incompatibility of these the two functions this is not generally possible.

Tree improvement is carried out by studying the character of gene. The variation of traits (e.g. growth rate, tree height, and fodder yield) are evaluated not only by genes, but also by the age of the tree, and its growing environment. For the living organisms, the genes are transferred from parents to offspring and therefore most of the expression of gene is under genetic control, offspring will express it well. If the environment is the major factor for variation, then differences will be less expressed. Genetic variation is causing most of the differences between: species; provenances; and individual trees. Once such variation is identified, the quality of seedlings used in future plantings, that can be improved by controlled seed collection, breeding and/or vegetative propagation of trees with genetically superior characters. Tree improvement programme can be classified into three main steps: 1. selection, testing and evaluation of trees. 2. Identification and establishment of genetically improved source. 3. Large scale production of improved varieties according to the tree improvement objectives. A large dominance variance in quantitative traits makes selection less predictable than with large additive variance and requires more complicated selection procedures to improve a crop (Morgenstern *et al.*, 1975).

Indira (1996) study the nature of genetic variability, heritability and correlation of economically important characters and breeding system prevailing in *Ailanthus triphysa* and also the Establishment of seed orchard. The study revealed that *A. triphysa* has a high family heritability for height and moderately high

heritability for basal girth. The single tree heritability was found to be moderately high for height while it was low for basal girth and decreased with age. The phenotypic and genotypic coefficient of variation were found to be low for height and collar girth Strong Since phenotypic variance was very low, genetic gain also happened to be low. High heritability was not accompanied by greater genetic progress. For basal girth, phenotypic and genotypic coefficient of variation were very low. Single tree heritability and genetic advance were also low. Family heritability was found to be moderate. Moderate family heritability and low single tree heritability for girth was attributable to non-additive gene effects. The genetic correlation between height and basal girth was found to be as high as 1.0, while phenotypic correlation was 0.69 at the age of three years. *Ailanthus integrifolia* ssp. *calycina* was found to be better in growth performance in early years besides having a high level of pest resistance. However, *Ailanthus triphysa* is considered superior due to an aromatic resin that is present in it removing the need splints to be dipped in wax. *A. triphysa* performed well in degraded soils whereas *A. integrifolia* failed to survive in small scale field planting done at various localities.

Clonal forestry or planting with genetically enhanced planting material is one of the perfect methods for constant productivity of the forest (Lal *et al.*, 1997). For attaining this objective, selection of phenotypical superior tree or Candidate Plus Trees (CPTs) is the most time consuming and pivotal step (Sankhyan *et al.*, 2015). The elemental procedure for any tree improvement programme is the selection of the superior genotype. The progress of any tree improvement programme depends on extend of genetic variability in a tree species and it has got significant value for developing useful tree improvement methods (Vakshasya *et al.,* 1992). The largest, cheapest and fastest achievement in most forestry tree improvement programme will gather if use of proper species and seed sources or clonal progression within species is guaranteed (Zobel and Talbert, 1984). Genetically improved plantations are the best advisable for the forest productivity and timber supply, these plantations will

help in the sustained productivity of the timber (Li *et al.*, 1999). The information on the nature and degree of variability and correlation in a population owing to genetic and non-genetic aspect is one of the essential in any hybridization programme for selecting parents with suitable traits (Majumder *et al.*, 2012). Heritability has an important position in tree improvement programme as it bring an index of relative vigour of heredity versus environment. Heritability is very important in tree improvement programme (Dorman, 1976).

Sankhyan *et al.* (2015) conducted an experiment in *Sapindus mukorossi* to determine the best seed source from twenty four seed sources. The range of seed source means were also found maximum germination percentage (83.83%) for S16 and minimum (59.00%) for S21), maximum in germination capacity (88.00%) for S16 and minimum (64.83%) for S21, germination energy maximum (48.67%) for S16 and minimum (28.17%) for S21. For improved genetic material, Banjar seed source was found to be superior and perfect followed by Garsa seed source for all traits.

Significant differences were recorded among the seed sources with respect to seed and seedling attributes while evaluating the performance of five seed sources (Chikmagalur, Uttara Kannada, Mandya, Dharwad and Gulbarga of *Albizia lebbeck* in Karnataka) of which seeds collected from Mandya and Chikmagalur sources showed better performance for germination attributes (Nayak *et al.*, 2004).

Ghildiyal *et al.* (2009) studied fourteen seed sources of *Pinus roxburghii* from Garhwal Himalaya, situated in the Western-Central Himalayan province of India. To assess additive genetic variation in seedling growth and biomass. Among different seed sources, the root length fluctuated between a minimum of 47.60 cm (in Badiyargarh seed source) to a maximum of 73.73 cm (in Kalimath seed source) and the maximum seedling biomass (11.372 g/seedling) was recorded for Thalisain seed source, while minimum (5.962 g/seedling) for Badiyargarh seed source, after

eighteen months of seedling performance . Heritability in broad sense for seedling height was connected with genetic advance and following gain. The phenotypic and genotypic coefficients of variance were evaluated for root length, root biomass, root /shoot ratio, seedling height and shoot biomass respectively. The highest environmental coefficient of variance was noticed for root length and lowest for collar diameter. The heritability (h) value along with Genotypic Coefficient of Variance (GCV) advice that production and quality of seedlings of *Pinus roxburghii* may be determined based on phenotypic coefficient of variance (PCV) of superior provenances.

Paul (2017) conducted an evaluation trial of the selected candidate plus trees of *Ailanthus triphysa* from the Thrissur and Palakkad district. For screening of *ailanthus triphysa* for preferred match wood qualities. He found significant variations between the selected CPTs in germination studies. The average germination per cent of 48.82 among the selected seed sources. The highest value was for seed source FCV AT 17 at 72.08 per cent and the lowest was for FCV AT 4 which was 21.67 per cent, and the peak value of germination was highest for FCV AT 17 (3.60). The mean daily germination for all the seed sources was averaged to 4.42 and germination value was highest for FCV AT 7 (25.28). From the field analysis, the plant height and collar diameter showed a significant difference among the selections. The FCV AT 1 was found the best performer at field condition. The candidate plus trees showed a significant difference in their performances by the selection.

Kumari and Wani (2015) evaluated the performance of thirty phenotypically superior trees from Madhya Pradesh, Chhattisgarh and Jharkhand for seed source variation in *Diospyros melanoxylon.* Mean performance of 30 plus tree progeny for different morphological and biomass characters showed maximum value for seedling height, number of leaves per seedling (13.18cm), (5.70) for S30, collar diameter (3.13mm) for S18, leaf area (25.17$m^2$) for S29, shoot fresh weight, shoot dry weight

and seedling biomass (3.58gm), (2.51 gm), and (3.66gm) for S27, root fresh weight, root dry weight (1.70gm), (1.30gm) for S10 and shoot/root ratio(2.36) for S20. The assessment of genetic parameters exhibit that shoot fresh weight had maximum PCV (45.08%) followed by collar diameter (29.95 %) and root dry weight (19.78 %). Genetic advance was recorded maximum for (26.38) followed by root dry weight (20.35) and collar diameter (13.16). PCV values were higher than the correspondence GCV values for most of the traits indicate that they are much influenced by the environment. Leaf area and height of seedlings showed improved results, which indicated additive gene action on these two traits. Therefore these two traits would give better results for improvement of *Diospyros melanoxylon* by simple selection.

Sharma and Bakshi (2014) carried out an experiment for finding out superior clones of *Dalbergia sissoo*, the research was conducted in a clonal seed orchard (CSO) established at Lachhiwala, Dehradun India. The experimental material contained 30 clones of *Dalbergia sissoo*, collected from India and Nepal. Clone 196 exhibited the highest height (20.17 m) and GBH (74.20m) while clone 93 and clone 89 exhibit the lowest height (7.17 m) and GBH (26.80 cm), respectively. High degree of variation (0.1% level) was detected in height and GBH after 13 years of plantation. On the basis of height parameter, genotypes 196, 198, 192, 123, and 235 were determined as superior performing clones while genotypes 196, 123, 194, 198, and 202 were superior on the basis of GBH. Clones from Gonda and Nepal were performing better than the clones of Rajasthan. With regard to biochemical contents, significantly high protein content was found in clone 198 (85.43 mg/gm fresh weight), while minimum content was observed in clone 89 (19.97mg/gm fresh weight).

Mohamed *et al.* (2015) conducted an experiment to improving the oil quantity and quality of *Aquilaria malaccensis* by selection of superior genotypes. They selected twenty two provenances from North-Eastern states of Assam (6), Tripura

(10) and Nagaland (6). Based on the morphological characters such as plant height, diameter, number of branches and clear bole height. Plant height exhibit a positive and highly significant correlation for Sturdiness Quotient at phenotypic (0.992) and genotypic (1.000) level and Volume Index at phenotypic (0.972) and genotypic (1.000) level. But the phenotypic and genotypic inter correlations were negative and non-significant for collar diameter (-0.124 and -0.780), number of branches (0.268 and 0.582), root length (-0.383 and -0.487), number of secondary roots (- 0.084 and -0.170) and root/shoot ratio (-0.903 and -0.955). Collar diameter showed positive and non-significant phenotypic correlations and significant genotypic correlations for root/shoot ratio (0.050 and 0.537). The phenotypic and genotypic inter correlation were positive for number of branches (0.093 and 0.028), and secondary roots (0.081 and 0.203).

Wani and Ahmad (2013) find out the field environment genetic variation of 20 plus trees of *Madhuca indica* from different regions of Allahabad and Uttar Pradesh. Analysis of variance showed highly significant differences ($P$ =0.05) among the 20 genotypes for all the characters. The highest value for germination per cent (90.00) was reported for S20 and lowest for S2 (35.00) per cent. The maximum value (3.21) for mean daily germination was exhibited by S20 minimum for S2 (1.25). The highest value (4.67) for peak value was revealed by S20 and lowest for S2 (2.00). The maximum Germination Value was recorded for S20 (15.00) and minimum for S11 (2.64). The maximum value for germination speed (1.37) was recorded for S20 and minimum for S19 (0.36). The maximum seedling height (24.02 cm) was recorded for S8 and minimum for S3 (13.00 cm). The maximum collar diameter (6.73 mm) was revealed for S20 and minimum for S1 (4.27 mm). The maximum value for inter-nodal length (3.25 cm) was observed for S7and minimum for S14 (1.48 cm). Maximum number of leaves per seedling (9.73) was noticed in S15 and minimum for S7 (6.00). The maximum leaf area (43.20 $cm^2$) was recorded for S20 and minimum for S7 (20.70 $cm^2$). The heritability values for leaf area (99.39%) , germination

speed (84.56%), germination per cent (77.90%), mean daily germination (76.70), seedling height (73.89) and inter-nodal length (72.59. the plus tree progenies of S20, S9, S12 and S19 accordingly have shown better germination and seedling growth performance for most of the characters.

Anand and Dwivedi (2014) selected fourty eight plus trees of *Bauhinia variegate* from the different parts of Himachal Pradesh, to study the relationship between the morphological and biomass traits both phenotypic and genotypic levels by a correlation study, He found out that a positive and highly significant correlation existed between collar diameter and fresh shoot weight (0.73), collar diameter and dry shoot weight (0.78), fresh shoot weight and dry shoot weight (0.85). The phenotypic correlation coefficients are positively and significantly correlated at phenotypic level with shoot fresh weight (0.65) whereas, collar diameter with fresh shoot weight (0.61) gave positive and significant correlated response. Fresh shoot weight exhibited highly significant and positive correlation with dry shoot weight (0.90), significant with fresh root weight (0.67), seedling height (0.65), collar diameter (0.61) and non-significant with rest of the traits. A significant and positive correlation was observed between dry shoot weight and fresh root weight (0.62), between collar diameter and number of nodes (0.64), collar diameter and number of leaves (0.65), collar diameter and leaf area (0.72). Seedling height showed highly significant and positive correlation with number of leaves (0.91), leaf area (0.99), fresh root weight (0.81) and dry root weight (0.85).

Krishnakumar *et al.* (2017) studied the field performance of 30 progenies of *Santalum album* from different places of Tamil Nadu. In the study, volume reported maximum phenotypic coefficient of variation (27.67%) and Genotypic Coefficient (33.18%) of Variation (GCV). Calculation of broad sense heritability exhibit high values for diameter at breast height (0.99%), basal diameter (0.96%), tree height (0.95%), crown height (0.94%) clean bole height (0.90%) and volume (0.69%) while

low heritability was observed for number of branches (0.29). which revealed that FCRISA 18 showed consistently superior performance in all growth attributes,

Raebild *et al.* (2003) carried out a provenance trial with 16 provenances of *Acacia nilotica* from Africa and Asia and five provenances of *Acacia tortilis* from Sudan. Each species had provenance of local control at Burkina Faso, West Africa. The survival percent of the provenances varying from below 10 to 100 percentage. The *Acacia tortilis* provenances from Sudan had a comparatively high survival percentage than *Acacia nilotica*. Two provenances of *Acacia nilotica* (Burkina07 and Senegal15) had a survival of 100 percentage, largest crown area, and more number of stems than the remaining provenances. Considering the height, the provenances Burkina07 and Senegal15, exhibit better than the average value. From the entire study the *Acacia nilotica* had an average annual increment of 1.1t $ha^{-1}$re, while in trial 10 the best provenance 10 produced 1.6 t $ha^{-1}$annually. From this trial, Burkina07 and Senegal15 are identified as the best provenance for almost all the traits.

Paray *et al.* (2017) conducted an experiment in *Salix alba*, the candidate plus trees (CPT's) were selected from of two districts (Ganderbal and Bandipora) of Kashmir valley by comparison tree method. The CPT-76 shows the highest tree height of 14.8m and CPT-18 has the lowest tree height of 9.9m. The maximum DBH (37.2cm) for CPT-11 and the minimum (20.5cm) for CPT-57 and CPT-76. Tree volume was calculated maximum ($0.98m^3$) for CPT-11 and minimum for CPT-24 ($0.24m^3$). Crown diameter recorded maximum (4.5m) for CPT-28 and minimum (2.5m) for CPT-18, CPT-45, CPT-63 and CPT-91. The superiority percentage of height ranged from 20.2 % to 44.0 % for CPT-51 and CPT-49, respectively. The CPT-70 shows the lowest superiority percentage in DBH of 35.9 % and highest for CPT-53 with 55.0 %. CPT-89 has the maximum superiority percentage of 201.2 % and lowest for CPT-37 with 150.4 % in volume.

Santoso (2011) experimented on of *Jatropha curcas* for their variations in seed and seedling character. Seeds were collected from 25 parental plants with a minimum of 10 capsules per inflorescence from West Nusa Tenggara, Indonesia. He analysed the wild genotypes population (p0) first improved population (ip-1). The higher variation was also found within each wild genotypes population (p0) than the first improved population (ip-1). Standard deviation of seed length in p0 was higher than in ip-1. West Lombok and Sumbawa genotypes had the maximum seed weight, and minimum for east Lombok. The maximum kernel weight for West Lombok, and minimum for Central Lombok. The highest seedling height of 22.9 cm for p0 and 23.7 cm for ip-1 at West Lombok genotype and the lowest for east Lombok genotype having 20.1 cm for p0 and 21.2 cm for ip-1. Number of leaves in wild population (p0) varied within five genotypes is in the range of 7.8 to 9.1, while in first improved population (ip-1) has 8.7 to 9.6. Collar diameter is ranged from 1.0 cm to 1.4 cm within the wild population (p0), and 1.1 cm to 1.4 cm within their first improved population (ip-1). Genotypes of West Lombok, Sumbawa, and Bima performed exceedingly better than those of Central Lombok and East Lombok. He found out the best seed sources of *J. Curcas* and these could present genetic variability gives breeders with materials in tree improvement program.

Sahoo *et al.* (2011) conducted an experiment in 53 candidate plus trees (CPTs) of *Pongamia pinnata* from Orissa, to determine seed source with high oil content for production of quality planting seedling for afforestation. The analysis of variance showed a significant variation among the 53 candidate plus trees of *Pongamia pinnata* with respect to pod and seed characters. The highest pod length was observed in CPT-32 and lowest in CPT-35. CPT-28 showed maximum 100-pod weight (488.20 g), and CPT-10 shows minimum 100-pod weight (230.60 g). The maximum seed length was noticed in CPT-30 and minimum in CPT-10. 100-seed weight was found to be maximum in CPT-25 (177.40 g) and minimum in CPT-17 (77.29 g). From the

study the CPT-28 exhibit high pod weight, and CPT-25 has high seed weight and plantation of these two clones as high oil yielder may be suggested for different agroforestry system.

Divakara and Das (2011) perform an evaluation of 23 genotypes of *Madhuca latifolia* from Jharkhand. To diagnose the high yielding Candidate Plus Trees (CPTs) of *M. latifolia* at fruiting stage. CPT-15 genotype shows the highest seed length of 39.1 mm, seed breadth (19.2 mm) in CPT–8 and CPT–9, aspect ratio (2.2) in CPT-6 and CPT-15, 2D surface area (501.4 $mm^2$ for CPT-9 and 491.6 $mm^2$ for CPT-3). CPT–16 reported maximum for 100 seed weight (282.4 g) and oil content (51.2%). CPT–3 (578.3 cm3) shows maximum volume index. Trait oil content and 100 seed weight give high heritability (93.5%) accompanied with moderate genetic advance of 17.2% and 15.6%, it indicated that, heritability is due to additive gene effects and selection may be effective.

Aslam *et al.* (2011) examined the amount of variability in cone and seed traits of *Pinus wallichiana.* Eighty eight plus trees were selected randomly from Kashmir Himalaya. Plus trees are identified by selecting 100 candidate plus tress with 500 check trees on the basis of quantitative and qualitative traits. The data report that length of cone varied from 16.20 cm to 25.30 cm, plus tree no. 15 reported the maximum length (25.30 cm) and minimum for plus tree no. 40 (16.20 cm). Maximum cone width (6.80 cm) was recorded in plus tree no.15 and minimum (3.46 cm) in plus tree no. 48. Highest cone weight (46.0 g) was recorded for plus tree no.15 and lowest (28.16 g) for plus tree no. 27. Maximum number of seeds/cone (90.66) was recorded for plus tree no.15 and minimum (41.66) for tree no. 66. Seed length varied from 5.33 mm to 13.33 mm with overall mean of 9.80 mm. Maximum seed length (13.33 mm) was recorded for tree no. 15 and minimum (5.33 mm) for tree no.66.

Kang *et al.* (2010) experimented on growth attribute of hundred families of *Agathis loranthifolia* having rotation age of 40 years, from West Java, Indonesia. Survival rate, collar diameter (DRC) and height growth (HT) were measured at the age of 0, 10 and 15 months. The survival rate was increased 13.5% at the age of 10 months and 18.5% at 15 months. After the age of 15 months average highest height was 47.35 cm and lowest of 33.98 cm and DRC has the maximum value of 0.62 mm and minimum of 33.98 cm. The mean height at the age of 15 months was 40.18 cm and collar diameter of 0.518 cm. The GCV was 7.19% and 5.22% at the age of 15 months for DRC and height. When selecting best 10, 20, 30 and 40 families out of 100 tested at age 15 months, for height growth shows high genetic gain. Heritability for DRC was higher than that for height, but the phenotypic standard variation of DRC was smaller than that of height.

Abengmeneng *et al.* (2015) conducted an experiment for calculating the heritability and genetic gain in height growth of *Ceiba pentandra.* Seeds were collected from 37 half-sib families from Ghana. They observed the Narrow Sense Heritability (h2) in height growth of 0.56, which means that 56% or more of the observed variation in height growth was genetically controlled. Genetic gain in height ranged from -52.82 to 37.30 cm/yr. Maximum genetic gain of 20.89% was observed from accession DNY 1, and lowest of -29.58% for accession TAN 1.

Shinde *et al.* (2012) evaluated 21 candidate plus trees (CPTs) of *Calophyllum inophyllum* from the Konkan region of Maharashtra. To study the variation and identify superior genotypes for seed character along the Konkan Coasts of Maharashtra. From the selection they found out 153 healthy individuals according to its fruit yield, seed trait and oil content. The comparison tree method was used for the selection of candidate plus trees (CPTs) of *Calophyllum inophyllum*. Kumar and Singh (2014) studied seed trait variabilities in *Jatropha curcas*. They selected 28 Candidate Plus Trees (CPTs) of *Jatropha curcas* from Bihar, West Bengal and

Jharkhand according to its seed quality, crown size and tree health. From the study, CPT J17 gives the maximum seed length, seed width, 2D surface area, aspect ratio and germination percentage. Largest 100-seed weight was found for J19 (74.35gm). CPT J18 shows maximum value for total soluble carbohydrate. Highest seed oil percentage was estimated in J27 (45.38%) and the minimum value in J22 (27.77%).

Chauhan *et al.* (2010) evaluated the progenies of *Pongamia pinnata* for their seed germination and seedling vigour. They selected 20 candidate plus trees (CPTs) of *Pongamia pinnata based on* fruit yield, seed quality and oil yield from the Konkan region, Maharashtra. The highest germination percentage (85.50%) was observed from, candidate plus tree of KKVPP-02 from Poynad region, and lowest for KKVPP-15 in Khed region with 16.50 per cent. Height of seedlings after six month of planting within progenies varies from 20.85 (KKVPP-01) to 46.2 cm (KKVPP-02). Leaf area is varied from 14.03 to 27.66 $cm^2$ among progenies of CPTs. the number of leaves (2.5– 17.5), root length (12.2–24.85 cm), and number of primary roots per seedlings (18–36.5). Shoot and root vigour indices varied significantly among genotypes. Shoot vigour index varied from 480.97 to 3950.1. The root index from 269.77–1515.25. The PezariPoynad region performed better for seed germination, whereas CPTs like KKVPP-06 and KKVPP-7, KKVPP-11, KKVPP-13, KKVPP-17 and KKVPP-18, performed better with respect to seedling growth characters. Hence the progenies of these CPTs can be advocated for the future afforestation and reforestation programmes in this region.

Dhaka *et al.* (2016) conducted a correlation study on *Bauhinia variegate* with their germination and seedling growth attributes to variability, heritability, genetic advance, and genetic gain. Seeds were collected from ten phenotypically superior mother natural populations of, Ahwa, Bardipada, Bhenskatri, Kalibel and Mahal from Dangs forest of Gujarat. The Bhenskatri and Mahal populations were superior over others for germination per cent and seedling growth attributes. The highest

germination per cent was recorded for Bhenskatri population (60.00), lowest for Ahwa population (16.24). The maximum collar diameter was noted for Bhenskatri population (3.37 mm) minimum value for Ahwa population (2.83mm). The maximum root length was found for Bhenskatri population (15.39 cm), minimum for Ahwa population (10.38 cm). germination per cent (29.76), root length (27.27) and number of leaves (22.90) and moderate for collar diameter (12.17), it revealed that, seedling height, germination per cent, root length, number of leaves are under the strong control of additive type of gene action.

Floistad *et al.* (2017) evaluated the seed sources of *Abies lasiocarpa* to determine the seed sources with potentially high survival and satisfactory christmas tree quality. The progenies are selected from six seed orchard clones at Kaupanger, Sognog Fjordane County, in western Norway. The average Christmas tree yield (63%) was obtained from Luster. The family 8114 from the Kaupanger seed orchard had the highest yield. Trees in the 67-2 family from Waterton Lakes National Park, Alberta, and the 53-1 family from Bridger-Teton NF, Wyoming, had significantly higher height/width ratio. Trees in the seed orchard family 8110 had the maximum number of branches in the uppermost whorl, with 6.7 branches. The number of branches and Christmas tree yield has a correlation ($r = 0.48$).

Palanisamy *et al.* (2008) selected forty one superior trees of teak from plantations in different locations in Kerala. The objective of the study was to evaluate the progeny performance. The selected trees were multiplied by coppice shoots. Clone NPT110 showed maximum height (35 m) and GBH (220 cm) with 100% rooting ability. Trees in Trissur had lower height of 17–29 m and GBH 132–168 cm. The trees from Panayancode exhibit a maximum height of 32–35 m. Maximum rooting of 100% was observed in clones NPT110 and NPT111. The numbers of roots were more in clones NPT15, NPT111 and NPT102 (4.0 to 4.2). The ortet of clone NPT110 was outstanding with maximum height of 35 m and GBH of 220 cm and

showed 100% rooting and maximum root length compared with other clones. The author concluded that NPT110 can be used for the large scale planting.

## 2.3 NURSERY EVALUATION

### 2.3.1 Seed attributes

Uniyal *et al.* (2003) found that seed weight is positively correlated with altitude of the seed source, and he observed highest seed weight (16.24 g/100 seed) for Ranikhe and lowest (8.44 g/100 seed) for Thati seed source. In *Pinus brutia,* the larger and heavier seeds formed better performing seedlings and high elevation families were little in germination and produced smaller seedlings than the middle and lower altitudes seed sources (Isik, 1986). Meena *et al.* (2016) studied the seed and seedling behaviour of *Tecomella undulata*. The weight of seeds from 0.6g to 1.04g 100 seeds/gm and the colour shows variations from light to dark. The length of the seeds with in seed sources was varying from 16.7mm to 22.2 mm and width from 8.3 mm to 9.3 mm. The variations in germination of seed due to the environmental factors also found in *Azadirachta indica* (Dwivedi, 1993) and *Jatropha curcas* (Geetanjali *et al.,* 2003).

Ghosh and Singh (2011) studied the variation of seed and seedling attribute of *Jatropha curcas*. Seeds were collected from diverse agro-climatic zones of India. The maximum seed length (19.06 mm) was found in seeds from Nainpur provenance, while Udaipur - 2 provenance had the lowest seed length (16.40 mm). The seed width varied between 10.17 mm (zone humid western Himalayan region). Within the zone humid western Himalayan region. PJ Set-1 had the highest seed weight. Within sub-humid Sutlej Ganga alluvial plains NRCAF-13 had the maximum seed weight. Analysis of variance recorded that different zones had no significant effect on

kernel/seed coat ratio. Among provenances, seeds collected from humid western Himalayan region's Jammu provenance has the highest oil content (38 %). Oyebade *et al.* (2012), in his study on provenance variations in *Chrysophyllum albidum* (G. Don) from six localities in Rivers state, Nigeria Seed source from Bori was found to have the highest germination percentage (53%) and less mortality rate (47%), whereas Bonny had the lowest germination percentage (21%) and more mortality rate (78.92%).

Shinde *et al.* (2012) evaluated plus trees (CPTs) of *Calophyllum inophyllum* shows highest fruit size and seed parameters like fruit diameter (39.36 mm), fruit length (44.05 mm), fruit volume (31.55 $cm^3$) and seed size ,seed volume (13.80 $cm^3$), seed diameter (31.47 mm) and seed length (40.58 mm) for the plus tree KKVCI-13. While highest seed oil content was observed in KKVCI03 (79.73 per cent. KKVCI-13 has had superiority over other CPTs for fruit and seed characters. Kumar and Singh (2014) studied seed trait variabilities in *Jatropha curcas* found that CPT J17 gave maximum seed length, seed width, 2D surface area, aspect ratio and germination percentage. Largest 100-seed weight was found for J19 (74.35). CPT J18 shows maximum value for total soluble carbohydrate. Highest seed oil percentage was estimated in J27 (45.38) and the minimum value in J22 (27.77). Korwar *et al.* (2008), studied the genetic associations, variability and diversity in seed characters, growth, reproductive phenology and yield in *Jatropha curcas* (L.) from 32 high yielding Candidate Plus Trees (CPTs) covering 11 locations. Significant trait differences were observed in all the seed characters (seed morphology and oil content), growth characters (plant height, and female to male flower ratio and seed yield in the progeny trial). Broad sense heritability was high in general and exceeded 80 per cent for all the seed traits studied. Female to male flower ratio showed near to 100 per cent heritability followed by yield (83.61) and plant height (87.73).

Divakara and Das (2011) evaluated 23 genotypes of *Madhuca latifolia* and observed that, CPT-15 genotype shows the highest seed length of 39.1 mm , seed breadth (19.2 mm) in CPT–8 and CPT–9, aspect ratio (2.2) in CPT-6 and CPT-15, 2D surface area (501.4 $mm^2$ for CPT-9 and 491.6 $mm^2$ for CPT-3). CPT–16 reported maximum for 100 seed weight (282.4 g) and oil content (51.2%). CPT–3 (578.3 $cm^3$) shows maximum volume index. Trait oil content and 100 seed weight give high heritability (93.5%, 93.0%) accompanied with moderate genetic advance of 17.2% and 15.6%, it indicated that, heritability is due to additive gene effects and selection may be effective. Aslam *et al.* (2010) examined the amount of variability in cone and seed traits of *Pinus wallichiana.* The data report that length of cone varied from 16.20 cm to 25.30 cm, plus tree no. 15 reported the maximum length (25.30 cm) and minimum for plus tree no. 40 (16.20 cm). Maximum cone width (6.80 cm) was recorded in plus tree no.15 and minimum (3.46 cm) in plus tree no. 48. Highest cone weight (46.0 g) was recorded for plus tree no.15 and lowest (28.16 g) for plus tree no. 27. Maximum number of seeds/cone (90.66) was recorded for plus tree no.15 and minimum (41.66) for tree no. 66. Seed length varied from 5.33 mm to 13.33 mm with overall mean of 9.80 mm. Maximum seed length (13.33 mm) was recorded for tree no. 15 and minimum (5.33 mm) for tree no.66.

### 2.3.2. Germination attributes

Bahar (2008) evaluated significant variation in germination per cent and vigour index within the seed sources of *Albezia lebbeck*. Seed germination varied from 62.80 per cent (Chandra nagar) to 96.36 per cent (Dehra Dun). Maximum vigour index (2022) was recorded in Nahan and minimum (1177) in Chinglepet seed source. Germination of *Populas ciliate* from different seed sources also exhibited significant difference in germination percentage with values ranging from 41.75 per cent in Kathpudia seed source to 71.55 per cent in Nainital seed source. Germination percentage was also tend to be positively and significantly correlated with shoot

length, root length, total seedling length, vigour index and number of leaves per seedling in poplar seedlings (Singh *et al.*, 2001). Hembrom *et al.* (2010), on the germination and germination speed in seeds of *Terminalia arjuna* and *Terminalia tomentosa* from different provenance reported highest germination (23.3%) in the seeds of *T. tomentosa* from Pipariya. Germination speed was lowest (83.33) in *T. arjuna* from Bahargoda in Jharkhand. The maximum (91.5) and lowest (69.0) values for percent of sound seed were reported for Malsi and Chham populations, respectively.

Sivakumar *et al.* (2002) studied on Variability in drupe traits and their relationship on seed germination in *Tectona grandis* seeds. Teak seeds collected from 30 sources covering India, Bangladesh and Laos. Kerala, Nilanmbur provenance exhibited highest germination per cent (49%) and Dehra Dhun exhibit least germination per cent (0.03%). Variations in germination percentage and germination energy was found in *Azadiracta indica* seeds among the different provenances from Jharkhand. Maximum germination percentage (72%) was found in Ranchi provenance and minimum (36%) in Giridih provenance and the germination energy was also maximum (38) in Ranchi following a similar pattern of germination percentage (Mahto *et al.*, 2006).

A study by Kumar *et al.* (2004) revealed variation in germination of seeds collected from 13 superior *Acacia catechu* trees at different locations studied on seed source variation in Samples of pods were collected from superior trees at 13 different places of Haryana, Jammu & Kashmir, Punjab and Uttaranchal. Intra-population variation in *Albizzia procera* was studied with respect to germination percentage, hard seed per cent among the 33 trees in Jabalpur. Huge variation was recorded in germination percentage among the seed sources *Albezia procera* with values varying from 20.00 per cent to 81.33 per cent and hard seed per cent varied from 1.33 per cent to 79.33 per cent (Gera *et al.*, 2001).

Germination parameters of *Jatropha curcus* seeds collected from 10 different seed sources shows considerable variations with highest germination and vigour index in Walayar and least from Paripati (Kumar, 2003). Bhat and Chauhan (2002) found that the germination percentage was positively correlated with seed size in *Albezia lebbeck*. Kaproth and McGraw (2008) studied germinability of *Ailanthus altissima* seeds floated and submerged in cages at two study sites (Monongahela river and Cheat lake). Seeds recovered from submerged cages retained high germinability (94.4%), showing no significant decline over a 5-month period. The effect of environment on seed germinability depended on site with germination at a lower rate on land (relative to those incubated in water) at Cheat Lake, but this pattern was not observed at the Monongahela river site. *Ailanthus altissima* seed that had floated for 3 days had an increased level of seed germination (87%), while a 20-day stay in water water-curbed germination to 32 per cent compared to 53 per cent in control (Kowarik and Saumel, 2007).

### 2.3.3 Root- attributes

Dhaka *et al.* (2016) conducted a correlation study on *Bauhinia variegate* with their germination and seedling growth attributes to Variability, Heritability, Genetic Advance, and Genetic Gain. Seeds were collected from ten phenotypically superior natural populations of, Ahwa, Bardipada, Bhenskatri, Kalibel and Mahal from Dangs forest of Gujarat. The maximum collar diameter was noted for Bhenskatri population (3.37±0.06 mm) minimum value for Ahwa population (2.83±0.02mm). The maximum root length was found for Bhenskatri population (15.39±0.54 cm), minimum for Ahwa population (10.38±0.32 cm). Mohamed *et al.* (2015) conducted an experiment for improve the species oil quantity and quality of *Aquilaria malaccensis*, by selection of superior genotypes. The root length (-0.383 and -0.487), number of secondary roots (- 0.084 and -0.170) and root/shoot ratio (-0.903 and -0.955). Collar diameter showed positive and non-significant phenotypic correlations

and significant genotypic correlations for root/shoot ratio (0.050 and 0.537). The phenotypic and genotypic inter correlation were positive for number of branches (0.093 and 0.028), number of secondary roots (0.081 and 0.203).

Chauhan *et al.* (2010) evaluated the progenies of *Pongamia pinnata* for their seed germination and seedling vigour. The root length (12.2–24.85 cm), and number of primary roots per seedlings (18–36.5). Shoot and root vigour indices varied significantly among genotypes. Shoot vigour index varied from 480.97 to 3950.1. The root index also followed a similar trend (269.77–1515.25) among CPTs. Ghildiyal *et al.* (2009) studied fourteen seed sources of *Pinus roxburghii* from Garhwal Himalaya, among different seed sources. The root length fluctuate between a minimum of 47.60 cm (in Badiyargarh seed source) to a maximum of 73.73 cm (in Kalimath seed source. indicates significant differences in root length and number of lateral roots among seed sources. At the time of final observation (i.e., after eighteen months of sowing) the average root length varied from 47.60 ±4.488 cm for Badiyargarh seed source to 73.73 ±9.605 cm for Kalimath seed source. However, the number of lateral roots among seed sources oscillated between 24.20 ± 2.267 to 36.4 ±1.990 lateral roots/seedling in the Mayali and Pauri seed sources respectively.

### 2.3.4 Shoot attributes

Uniyal *et al.* (2003) experimented in seeds of *Grewia oppositifolia,* collected from Central Himalaya from November 1994 to January 1995. Average shoot length after 12 months growth ranged from 58.6 to 89.5 cm, irrespective of the provenance. Chilledi was the provenance that showed the highest shoot length followed by Malsi and Dov, whereas, Srinagar had the lowest shoot length (58.6 cm), The maximum root length (87.1 cm) and root collar diameter (9.2mm) were recorded for the Malsi population. The number of leaves per seedling varied from 7.3 (Simswara) to 14.5 (Chham) among the provenances. The number of branches per plant was found to be

highest (5.2/plant) in Guptakashi and lowest (2.5/plant) in Nauni, Karanpryag and Shyalde populations.

Three month old seedlings of *Tecomella undulate* were measured for shoot height and shoot vigour index for each of the progenies. Results greatly varied among the progenies from 12.5cm (CPT-19 from Bikaner) to 39.8 cm (CPT-4 from Nagaur). Sixteen CPTs showed higher seedling height of more than 30 cm. Shoot vigour indices varied significantly among genotypes which ranged from 511.5 (CPT-29 from Sikar) to 3345 (CPT-4 from Nagaur). With respect to seedling height and shoot vigour index, CPT-4 from Nagaur districts performed better in comparison to other. This variation is mainly attributed to genetic and environmental factors which affect the seedlings growth (Meena *et al*, 2016). Similar trend has also been documented among seed sources for vigour indices in many tropical species like *Pongamia pinnata* (Patil, *et al*., 2011), *Jatropha curcas*(Geetanjali *et al.,* 2003).

Wani and Ahmad (2013) found out the field environment genetic variation of 20 plus trees of *Madhuca indica* from different regions of Allahabad and Uttar Pradesh. The maximum seedling height (24.02 cm) was recorded for S8 and minimum for S3 (13.00 cm). The maximum collar diameter (6.73 mm) was revealed for S20 and minimum for S1 (4.27 mm). The maximum value for inter-nodal length (3.25 cm) was observed for S7 and followed by S14 (1.48 cm). Maximum number of leaves per seedling (9.73) was noticed in S15 and minimum for S7 (6.00). The maximum leaf area (43.20 $cm^2$) was recorded for S20 and minimum for S7 (20.70 $cm^2$). A correlation study on *Bauhinia variegata* with their germination and seedling growth attributes. The maximum number of leaves per plant was reported from Bhenskatri population (10.21±0.24) and minimum for Ahwa population (7.52±0.19). Highest GCV was recorded for seedling height (23.01%), and the lowest GCV was recorded for collar diameter (6.58 %). Higher genetic gain for seedling height (43.98 %) (Dhaka *et al*, 2016).

Maximum value for seedling height, no. of leaves/seedling (13.18), (5.70) for S30, collar diameter (3.13mm) for S18, Leaf area (25.17 $cm^2$) for S29. Leaf area and height of seedlings showed improved results, which indicated additive gene action on these two traits. Therefore these two traits would give better results for improvement of *Diospyros melanoxylon* by simple selection (Kumari and Wani, 2015). But the phenotypic and genotypic inter correlations were negative and non-significant for collar diameter (-0.124 and -0.780), number of branches (0.268 and 0.582) (Mohamed *et al*, 2015).

Chauhan *et al.* (2010) evaluated the progenies of *Pongamia pinnata* for their seed germination and seedling vigour. Height of seedlings after six month of planting within progenies varied from 20.85 (KKVPP-01) to 46.2 cm (KKVPP-02). Leaf area varied from 14.03 to 27.66 $cm^2$ among progenies of CPTs. the number of leaves (2.5–17.5), significant variation among progenies, except collar diameter and primary root length. After six months, seedling height greatly varied among progenies of CPTs, from 20.85 (KKVPP-01) to 46.2 cm (KKVPP-02). Six CPTs showed higher seedling height of more than 40 cm. Leaf area is one of the potential characters of the plant that positively influences seedling growth. In the present study, leaf area varied from 14.03 to 27.66 $cm^2$ among progenies of CPTs. Such a range of variations has also been recorded among CPTs for other seedling parameters like number of leaves (2.5–17.5), the minimum average seedling height was observed for Badiyargarh (34.40 ±2.447 cm) seed source. Similarly, after eighteen months of age, the average collar diameter of the seedlings of various seed sources ranged from a minimum of 0.52 ±0.022 cm for Ghansali to 0.71 ± 0.065 cm for Jasholi seed source and exhibited significant differences among other seed sources.

### 2.3.5 Biomass attribute

From the evaluation of plus trees of *Grewia oppositifolia* seeds, the maximum (8.2 g/plant) seedling dry weight was recorded for Chilledi and the minimum (3.1 g/plant) for Dov populations. Root to shoot ratios exhibited the highest (1.42) value in Bilkhet and the lowest (0.58) in Mayall populations (Uniyal *et al*, 2003). Wani and Ahmad (2013) estimateed the pattern of field environment genetic variation for twenty genotypes of *Madhuca indica and* found maximum shoot fresh weight (8.77 g) for genotype S20 and minimum for S1 (5.37 g). The maximum shoot dry weight (2.14 g) was noticed for S20, and minimum for S14 (1.32). For the species *Madhuca indica*. The performance of thirty phenotypically superior trees from Madhya Pradesh, Chhattisgarh and Jharkhand were examined for seed source variation in *Diospyros melanoxylon*, the shoot fresh weight, shoot dry weight and seedling biomass (3.58), (2.51), and (3.66) for S27, root fresh weight, root dry weight (1.70), (1.30) for S10 and shoot/root ratio (2.36) for S20. The assessment of genetic parameters exhibit that shoot fresh weight had maximum PCV (45.08%) followed by collar diameter (29.95 %) and root dry weight (19.78 %). Genetic advance was recorded maximum for (26.38) followed by root dry weight (20.35) (Kumari and Wani, 2015).

Anand and Dwivedi (2014) selected fourty eight plus trees of *Bauhinia variegate* from different parts of Himachal Pradesh, to assess the association among different morphological and biomass traits. They got, dry shoot weight (0.78), fresh shoot weight (0.85). The phenotypic correlation coefficients are positively and significantly correlated at phenotypic level with shoot fresh weight (0.65) whereas, collar diameter with fresh shoot weight (0.61) gave positive and significant correlated response. Fresh shoot weight exhibited highly significant and positive correlation with dry shoot weight (0.90), significant with fresh root weight (0.67), seedling

height (0.65), collar diameter (0.61) and non-significant with rest of the traits. A significant and positive correlation was observed between dry shoot weight and fresh root weight (0.62), between collar diameter and number of nodes (0.64), collar diameter and number of leaves (0.65), collar diameter and leaf area (0.72).

Kumari and Wani (2015) evaluated the performance of thirty phenotypically superior trees from Madhya Pradesh, Chhattisgarh and Jharkhand for seed source variation in *Diospyros melanoxylon*. The phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the morphological and biomass traits. The maximum variance among replication (41.30) was observed for seedling biomass and minimum (0.01) for seedling diameter. The maximum heritability on plus tree family basis ($h^2F$), was observed for shoot dry weight (0.963) followed by leaf area (0.956) and seedling height (0.954). Heritability within family basis ($h^2w$) was found to be maximum for shoot dry weight (0.814) followed by seedling height (0.713) and leaf area (0.706). However, maximum heritability on individual plant basis ($h^2I$) was recorded for shoot dry weight (0.852) followed by leaf area (0.752) and seedling height (0.750). Therefore traits (shoot dry weight, leaf area and seedling height) were under the strong genetic control (Dean and Burdon, 1991). In all the traits, family heritability ($h^2F$) was higher than the individual tree heritability ($h^2I$) and within family heritability ($h^2w$).

Chauhan *et al.* (2010) evaluated the progenies of *Pongamia pinnata* for their seed germination and seedling vigour. They selected twenty candidate plus trees (CPTs) of *Pongamia pinnata* based on fruit yield, seed quality and oil yield from the Konkan region, Maharashtra. The shoot weight ranged from 1.75 to 5.32 g, root weight from 0.64 to 4.07 g, and leaf weight from 0.18 to 5.22 g. Dry biomass of shoot, leaf and root did not show significant difference among progenies of 20 CPTs, where these individuals were grown in a nursery that may have been exposed to competition for light, nutrients and moisture.

From a study conducted by Ghildiyal *et al.* (2009) for assessing the seed sources of *Pinus roxburghii* from Garhwal Himalaya, the maximum seedling biomass (11.372 g/seedling) was recorded for Thalisain seed source, while minimum (5.962 g/seedling) for Badiyargarh seed source, Biomass production in various production units (viz., shoot, root and total seedling biomass and root-shoot ratio) on dry weight after eighteen months of growth have manifested the values for (i) shoot biomass, (ii) root biomass, and (iii) total seedling biomass production as; (i) 3.312 ± 0.453 to 7.678 ± 1.703 g/seedling for Ashtavakra and Thalisain seed sources, (ii) 2.054 ±0.263 to 5.210 ±2.262 g/seedling for Badiyargarh and Pauri seed sources, and (iii) 5.962 ±1.650 to 11.372±2.186 g/seedling for Badiyargarh and Thalisain seed sources . Maximum root-shoot ratio after eighteen months of age, oscillated between 0.469 ± 0.096 for Badiyargarh seed source to 0.891 ±0.146 for Kalimath seed source.

### 2.3.6 Seedling performance

Patil *et al.* (2011) evaluated variability for seed characters of *Pongamia pinnata* of different agro climatic zones of northern Karnataka. The seedling of Northern dry zone exhibit higher shoot length (35.94 cm), root length (34.23 cm), shoot dry weight (3.37g), root dry weight (3.37g), shoot vigour index (3286.90) and root vigour index (3136.90). The better seed source performance by Northern dry zone and least for North eastern dry zone. The provenances of *Sclerocarya birrea* at five and eight months showed high significant difference between height of seedlings and root collar diameter. But there is no significant differences between percentage increment of height and root collar diameter at eight months (Dlamini, 2010). The heritability values of all the characters of *Eucalyptus tereticornis* clone is high for volume, collar diameter, number of branches (Sasikumar, 2003).

Takuathung *et al.* (2012) evaluated the growth performance of *Senna siamea* (Lam.) from the nine provenances of Thailand. Seedling height changed from 53-85

cm with related to Genetic effects and diameter at ground level ranges from 33-62 mm. Oyebade *et al.* (2012) has studied the provenance variations of *Chrysophyllum albidum* from six provenance of Nigeria. Ahoada gives the maximum seedling height of 36.84 cm and minimum for Bonny provenance with seedling height of 12.45 cm.

For *Azadirachta indica* height was the most decidable character for selection in nursery stage. Among the experimented progenies all of them shows a significant variations for seedling height, stem height and number of progenies (Dhillon, 2003). In *Simarouba glauca,* the seed sources exhibit variations in collar diameter, plant height, leaf area index and number of leaves in its early growth. Chauhan *et al.* (2011) reported the seedling growth parameter and had shown significant variation among progenies of *Pongamia pinnata,* except collar diameter and primary root length.

Jayasankar *et al.* (1999) conducted an experiment in seedling traits of *Tectona grandis.* After 360 days of sawing, maximum leaf area (4663.6 $cm^2$) for Parambikulam provenance and minimum for Trichur (2003.9 $cm^2$).Bahar (2008) evaluated 29 seed sources of *Albizzia lebbeck* reported that best population on the basis of weight, germination percentage and vigour index were Dehradhun (Uttarakhand), Kathua (J&K) and Tirunelveli (Tamil Nadu). Singh and Sofi (2011), the clonal variation of seed traits, germination and seedling growth in *Dalbergia sissoo* among 20 clones originating from different agro-climatic conditions of four northern states (Uttar Pradesh, Rajasthan, Haryana and Uttarakhand) in India were evaluated. Seedling height was greatest in clone 204 (62.16 cm) and least in clone 85 (30.64 cm). The root collar diameter varied from 3.35 mm to 6.60 mm and it was maximal in clone 204 and minimum in clone 85. Rawat and Bakshi (2011) examined the variation in seedling traits of *Pinus wallichiana.* From 20 provenances in Himachal Pradesh and Uttaranchal. The height of Seedling ranges from 5.58 cm to 8.31 cm and coefficient of variance of 20.80 per cent, collar diameter ranges from

6.28 mm to 8.88 mm with coefficient of variance of 8.79 per cent and vigour index exhibited coefficient of variance of 48.62 per cent.

Liu *et al.* (2002) evaluated the seedling height, root biomass, total biomass, number of leaves and diameter growth of *Camptotheca acuminata*, from eighteen provenances of China. The height and diameter had significant differences among the all provenances. Provenance 14 exhibit maximum height growth (114 cm), and Provenance 2 was the least (71 cm). There is significant difference in the production of biomass for all the provenances. Rao *et al.* (2008) evaluated the genetic associations, variability and diversity in seed attributes, growth, reproductive phenology from 32 Candidate Plus Trees (CPTs) of *Jatropha.* The growth characters shows significant difference among all the populations. Maximum plant height of 134.0 cm was reported in CRDJ 24. Dabgar, *et al.* (2007) reported on seed source variation for seed and seedling traits in *Jatropha curcas* (L.). The seed source from Gudnapura (CPT-15) of Uttara Kannada district and Bankapura (CPT-17) of Haveri district exhibit better performance among the all seed sources.

Moya *et al.* (2012) reported the significant differences of sixteen provenances of *A. mangium* from Costa Rica. The seedling characteristics had the high genetic variations. After 3.5 months of observation Indonesia, Papua New Guinea and Queensland provenances shows better height growth as well as collar diameter. The basal diameter ranges between 1.7 mm for Oriomo River, Papua New Guinea and 3.2 mm for W. of Morehead, Papua New Guinea.

## 2.4 FIELD PERFORMANCE

Cornelius (1994) suggested that plus tree progeny will show better growth characteristics than their control. From his study he found that genetic gain up to 15 per cent for height and diameter and for volume the gain was 35 per cent achieved by plus tree selection, which depends on selection intensity, genetic variance, and heritability. The achieved improvement of a trait will enhance in the field performance. The loblolly pines grown in first generation orchards produce seven per cent to 12 per cent more volume than pines from wild stand. The second generation orchards produce 50 per cent more seeds than the 1st generation from the tree improvement study of *Ailanthus triphysa* and *Ailanthus integrifolia* ssp. *Calycina,*.

Ginwal and Gera (2000) studied the genetic variation of seed germination and growth performance of 12 *Acacia nilotica* provenances in India. Seed germination characteristics and growth traits of 12 different populations over the natural range in India. A significant difference between the provenances was noticed in respect of seed germination and growth (height, diameter, survival percentage) of 42 months in the field. Survival varied significantly at age after 42 months after field planting with T6 provenance outranking the rest. Although T4, T7, T8, T11 and T12 provenances maintained their superiority over the others, T6 provenance shows the maximum height (238.26 cm), collar diameter (3.33 cm) and better field survival (70.70 %).After two year of field planting highest survival per cent was observed from *A. triphysa* (78.66%) and for *A. integrifolia* (63 %). Family No. 4 exhibit better survival for *A. integrifolia (*83.33 %). *A. triphysa* was more susceptible for insect attack as compared to *A. integrifolia* ssp. *calycina*. Growth and insect pest resistance was more for *A. integrifolia* ssp. *Calycina* compared to *A. triphysa.* The performance of *A. triphysa* was better in degraded soil (Indira, 1996).

Lazdiņa *et al.* (2016) evaluated the early growth and frost damage in 23 five-year-old poplar clones in Latvia. The height varied from 273.3 to 711.0 cm. clones LV3, LV1 and LV4 was significantly higher than the other clones and had the highest biomass and beat others by 65 per cent. The greater extend of genetic control of height for loblolly pines was at the age of eight and its intra class correlation coefficients was 0.30. While at the age of four and twelve was 0.22, 0.27 respectively (McKeand, 1988). Brodie and Debell (2004) experimented the field performance of poplar clones by use of competition indices. From the testing of 4 clones 3 were *Populus trichocarpa* x *P. deltoides* hybrids and one was a local *Populus trichocarpa* clone. After the first growing season Diameters ranged from 0.2 to 4.2 cm and heights from 1.3 to 5.2 m. Verma and Bangarwa (2007) evaluates the PCV and GCV shows broad amount of genetic variability for number of branches, clear bole height, total height and basal diameter in *Populus deltoids*.

Meena *et al.* (2014) evaluated growth parameters of 54 *Melia azedarach* progenies from 11 geographical locations in India, at a seed farm of Punjab. The largest variations were recorded in the number of branches (35.63%), DBH (26.89%), basal diameter (25.25%), and MAI for DBH (25.07%). Total height (16.01%) had the lowest variation. Lowest heritability was recorded in total height, basal diameter, and DBH at the progeny level. The variations among various provenances of *Populus alba* were observed with respect to height, diameter at breast height (DBH), taper, clear bole, leaf area and number of stomata (Ramesh and Khurana, 2003)

# MATERIALS AND METHODS

# MATERIALS AND METHODS

The present study on 'Selection and evaluation of superior planting materials of *Ailanthus triphysa* (Dennst.) in Thrissur' was conducted to evaluate the initial growth performance of selected superior progenies from the candidate plus trees of *Ailanthus triphysa* in the tree nursery as well as in the field environment. The research materials and the details of methods and designs followed for the study are described in this Chapter.

## 3.1 MATERIALS

The experimental materials for this study consisted of 12 *Ailanthus triphysa* candidate plus trees (CPTs). They were selected from different locations of Thrissur district giving due representation to all the three agro-ecological zones viz. Malayoram, Central midland and Coastal sandy areas. Nursery experiments were carried out at College of Forestry Vellanikkara, Kerala and field trial was established at Instructional Farm, College of Horticulture, Kerala Agricultural University, Vellanikkara.

## 3.2 METHODOLOGY

### 3.2.1 Collection of seed

After a preliminary survey through the agro ecological zones of Thrissur district a total of 12 CPTs were identified and selected for the experiment. Four candidate plus trees were selected from each of the agro ecological zones based on comparison tree method. The selection of the plus trees are based on growth rate, timber form, freedom from diseases and insects, yield, individual-tree height, stem diameter or volume is generally the highest priority trait in plus-tree selection. The seeds were collected by lopping the seeded branches for avoiding the mixing of seeds

from nearby individuals. The CPTs were selected from Chalakkudy (Malayoram), Mala (Central midland), and Mathilakom representing Coastal sandy region (KAU, 2002).

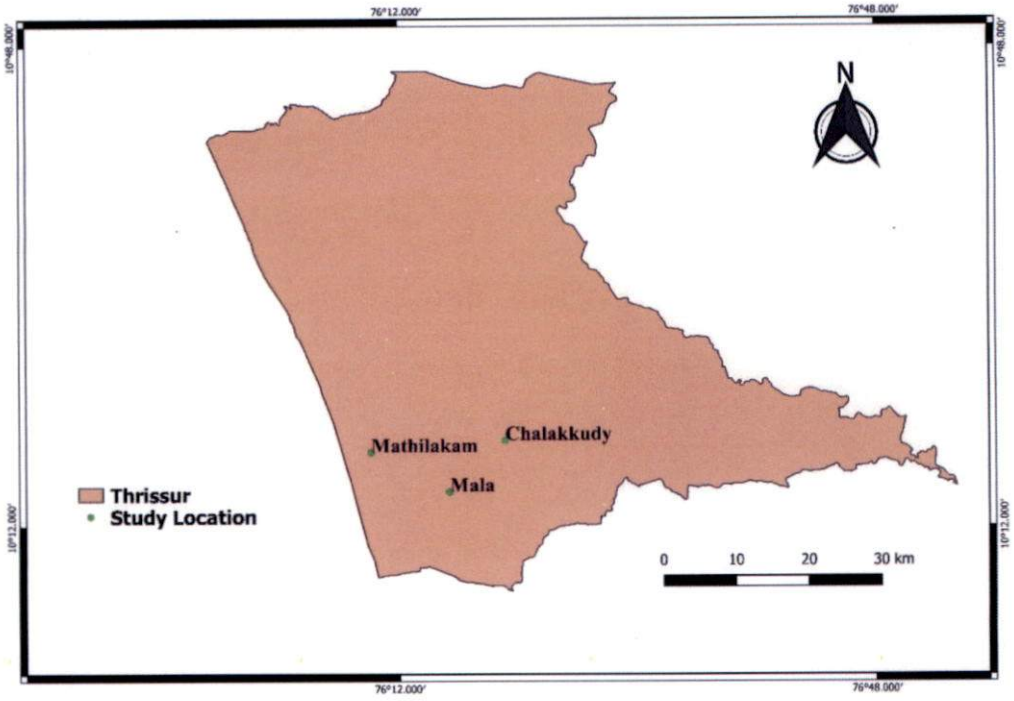



Plate1. Study location

### 3.2.2 Seed pre-treatment and sowing

The collected seeds were dried uniformly under the sun and insect attacked ones were removed. The de-winged seeds were subjected to 12 hours of overnight water soaking and sown uniformly by broadcasting over the prepared nursery bed. The nursery experiment was carried out at tree nursery, College of Forestry, Vellanikkara. The germinated seeds, at two-leaf stage, were transplanted uniformly to the polybags and kept in shade house. The potting mixture consisted of soil, cow dung and coir pith in the ratio of 2:1:1.

Table 1 Details of the candidate plus trees (CPTs) selected for the study

| Tree No. | Tree Height (m) | Girth at breast height (cm) | Representative Agro-ecological zones |
|---|---|---|---|
| **CPT-1** | 21 | 135 | Malayoram |
| **CPT-2** | 22 | 136 | |
| **CPT-3** | 21 | 128 | |
| **CPT-4** | 22 | 136 | |
| **CPT-5** | 23 | 126 | Central midland |
| **CPT-6** | 19 | 136 | |
| **CPT-7** | 24 | 138 | |
| **CPT-8** | 24 | 136 | |
| **CPT-9** | 20 | 120 | Coastal sandy |
| **CPT-10** | 23 | 140 | |
| **CPT-11** | 23 | 136 | |
| **CPT-12** | 21 | 143 | |

3.3. NURSERY OBSERVATIONS

Three best seedlings were selected from each of the candidate plus trees and recorded different growth parameters at 30 days of interval for a period of 180 days after planting (DAP). The statistical design for the analysis of nursery data was Completely Randomized Design (CRD).

### 3.3.1 Germination studies

For the germination trial, there are four replications from each of the candidate plus trees and one replication consisted of 100 healthy seeds. The seeds were sown on a seed bed of size 12m × 1.2 m × 0.3 m. The bed was mulched uniformly with leaves till the start of germination. The seeds were watered regularly with a rose can. The observations were taken for a period of four weeks from the starting of the germination to the completion of the germination. The germinated seeds were counted daily and calculated the germination parameters such as germination per cent (GP), peak value of germination (PV), mean daily germination (MDG), and germination value (GV) using the following formulae.

$$\text{Germination percent (GP)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

$$\text{Peak value of Germination (PV)} = \frac{\text{Total germination per cent}}{\text{Total number of days}}$$

$$\text{MDG} = \frac{\text{Final germination per cent}}{\text{The number of days that took to reach peak germination}}$$

$$\text{GV} = \text{Final mean daily germination (MDG)} \times \text{Peak value of germination (PV)}$$


Plate 2. Prepared nursery bed


Plate 3. Seeds sown in the seed bed


Plate 4. Seed bed mulched

Plate 5. Dried mulch


Plate 6. Mulch removed as seed germination proceeds


Plate7.Transplanted seedlings

Plate 8. Taking biomass observations

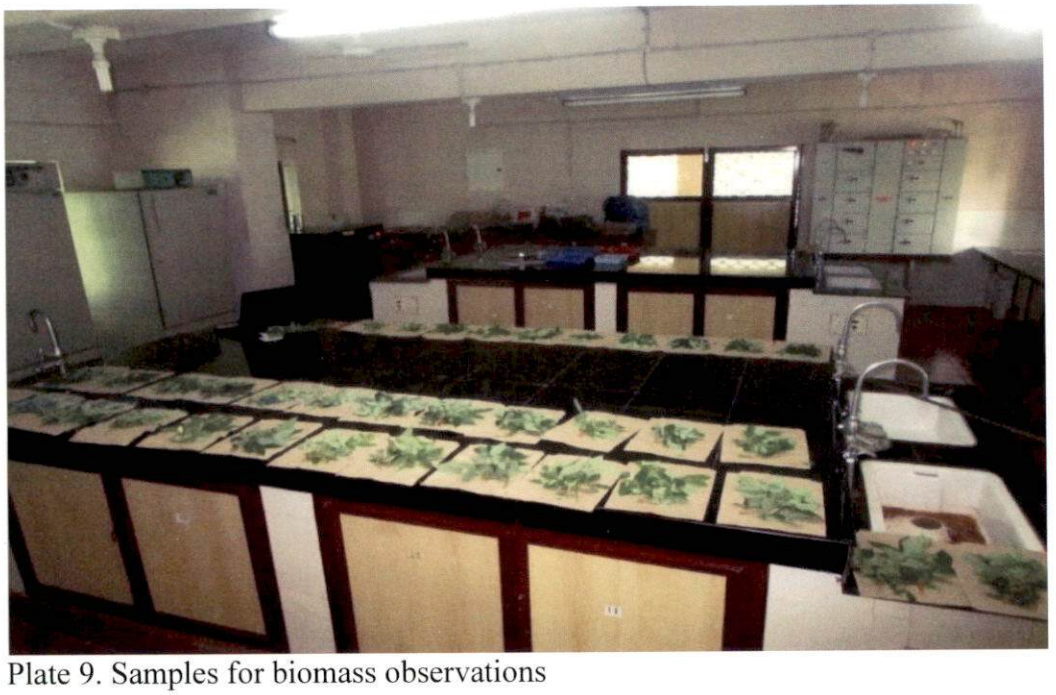


Plate 9. Samples for biomass observations

### *3.3.2.* Biometric observations

The biometric observations were taken by destructive sampling at the soil science laboratory of Dept. of Silviculture and Agroforestry, College of Forestry, Vellanikkara. Three randomly selected seedlings were uprooted and observed for each of the candidate plus trees at 30 days of intervals. Following biometric observations were taken up to a period of 180 days after planting.

**A. Plant height**

The height of the seedlings measured from collar to the terminal bud with a meter scale and expressed in centimetres.

**B. Collar diameter**

The diameter measurements were taken at the collar region of the seedlings using electronic digital vernier callipers in millimetres.

**C. Number of leaves**

The functional leaves (fully opened) were counted and recorded at 30 days of interval up to 180 DAP.

**D. Number of leaflets**

Counted the number of twigs produced by each seedlings at an interval of 30 days.

**E. Tap root length**

The length of the taproot was measured in cm down from collar to the tip of the tap root by using a meter scale.

**F. Number of secondary roots**

The number of roots emerging from the tap root were counted and recorded for each seedling.

**G. Number of tertiary roots**

The number of lateral roots produced from the secondary roots of individual seedlings was recorded manually at an interval of 30 days.

**H. Root- shoot length ratio**

Root- shoot length ratio was worked out at monthly intervals using the formula

$$\text{Root} - \text{Shoot length ratio} = \frac{\text{Root length (cm)}}{\text{Shoot length (cm)}}$$

**3.3.3 Biomass observations**

After evaluating the biometric observations of the same progenies of plus trees were subjected to calculate its fresh and dry biomass.

**A. Fresh weight of shoot**

The shoot portion was separated by using a sharp scissors. The fresh weight of shoots was recorded using electronic balance and expressed in grams.

**B. Dry weight of shoots**

After recording the fresh weight, the same shoot portion was dried in hot air oven at a temperature of 70°C ± 2°C for 48 hours till constant weight. The dry weight was recorded using an electronic balance and expressed in grams.

**C. Fresh weight of roots**

The fresh weight of each samples were taken by using an electronic balance and expressed in grams.

**D. Dry weight of roots**

The root portion was dried in hot air oven at a temperature of 70°C ± 2°C for about 48 hours till constant weight. The dry weight was recorded using an electronic balance and expressed in grams.

**E. Root- Shoot biomass ratio**

Root-shoot biomass ratio was worked out at 30 days of interval using the formula

$$\text{Root} - \text{Shoot biomass ratio} = \frac{\text{Root weight(g)}}{\text{Shoot weight (g)}}$$

## 3.4 FIELD OBSERVATIONS

For evaluating the initial growth performance of plus tree progenies, three best seedlings were selected from each of the candidate plus trees. A total of 108 seedlings were planted by square planting with spacing of 3m × 3m between plants and rows. The experimental plot was laid out in a randomised block design. An additional row of bulk seedlings of *Ailanthus triphysa* were also planted all along the borders to eliminate the border effect. For the field planting, area was prepared manually and aligning and staking was done. After staking, the planting pit was prepared with dimensions of 30 cm × 30 cm x 30 cm. The coir pith compost was used uniformly in the pits as a basal dose for the seedlings. After the field planting, the individual seedlings were protected by tree guards and the entire field by fencing. Protective irrigation was given uniformly during the summer months and weeded once in a month for the better growth of the seedlings. The attack of insect *Eligma narcissus* was controlled by the application of the 1 % ekalux on lower portion of the leaves. The observations were taken at 30 days interval from 30 DAP to 180 DAP.

Plate10. Field cleared for planting

Plate11. Alignment and staking for field planting

Plate12. Field after staking

Plate13. Preparation of planting pits

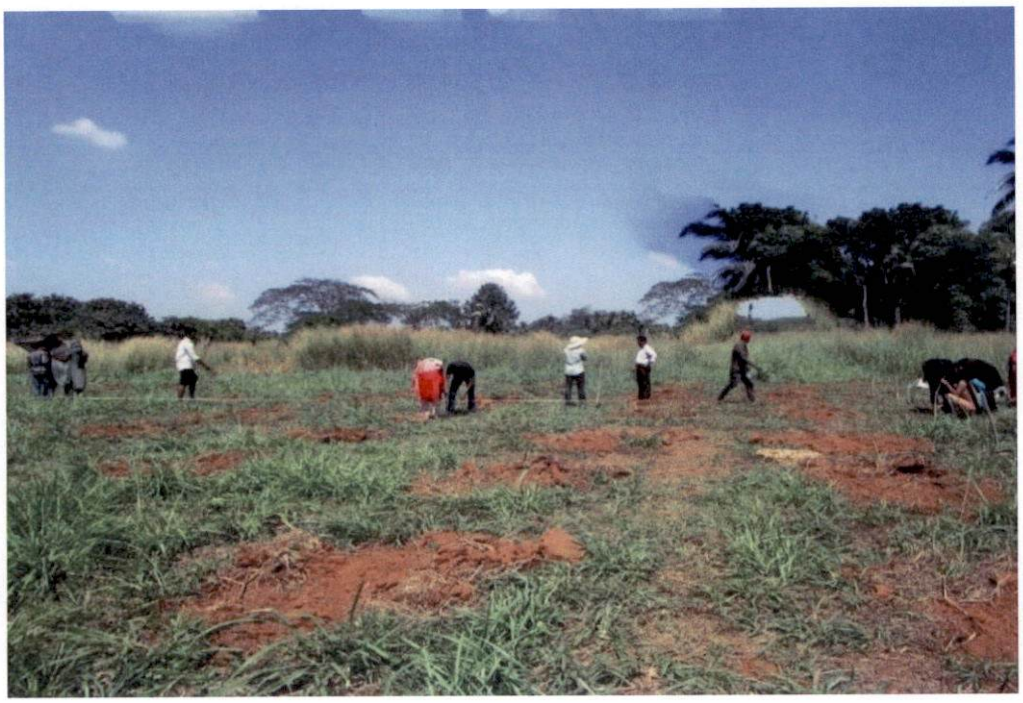


Plate14.Staking after pit making

Plate15. Fenced field

Plate 16. Field planting

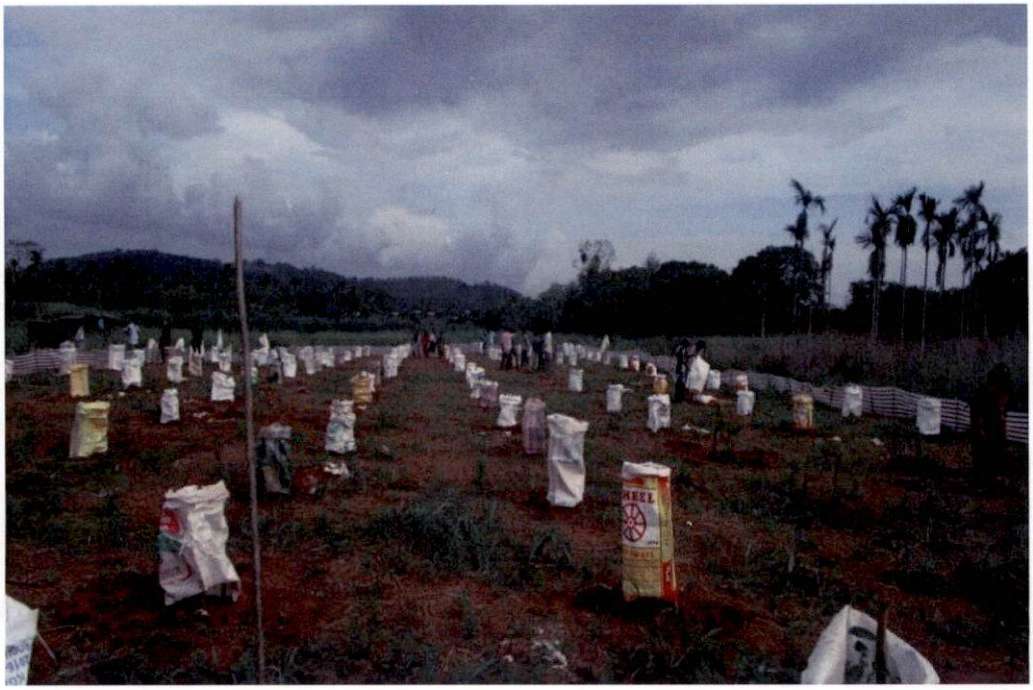


Plate17. Installation of individual tree guards

Plate18. Field after 180 DAP

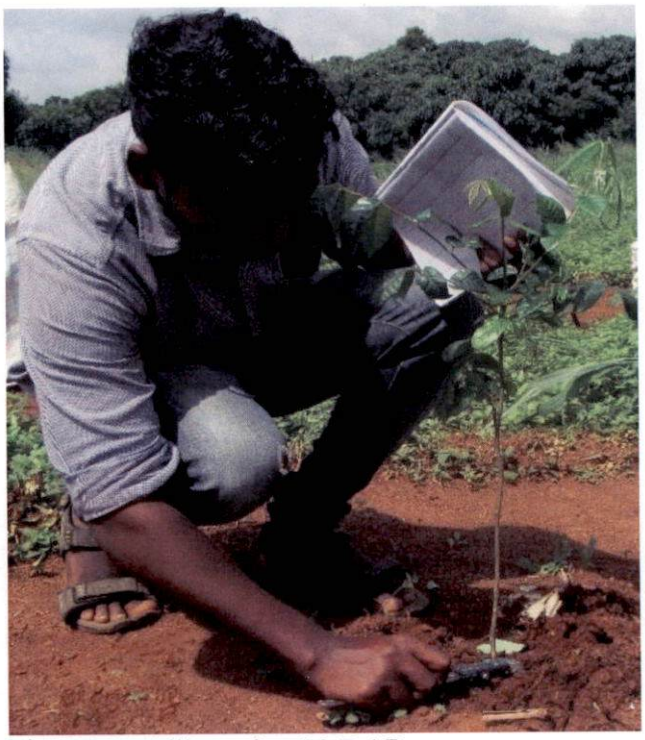


Plate19. Seedling after 30 DAP

Plate 20.A superior seedling (CPT-11)

### 3.4.1 Survival percentage

The survival percentage was calculated by counting the established seedlings in the field and the mean was expressed as percentage.

### 3.4.2 Collar diameter

The collar diameter was measured at the lowest portion of the seedlings planted near to the soil by electronic digital vernier calliper in millimetre.

### 3.4.3 Plant height

The height of the seedling was measured from the base of the stem at ground level to the tip of the plant by using a metre scale and expressed in centimetres.

### 3.4.4 Number of leaves

The number of leaves counted at an interval of 30 days for 180 DAP

### 3.4.5 Number of leaflets

Through the period of observation, counted the total number of leaflets of each individual progeny at an interval of 30 days for 180 DAP.

### 3.4.6 Number of forking

During the field performance of the study some progenies showed multiple stems, which is also counted and recorded for the analysis of the growth performance of the progenies.

# RESULTS

# RESULTS

The present study was carried out for selection and evaluation of superior planting materials of *Ailanthus triphysa* and also to assess the initial growth performance of seedlings planted. The results obtained are presented hereunder three sections viz. germination parameters, nursery performance and field evaluation.

## **4.1** GERMINATION PARAMETERS

The germination attributes of the selected candidate plus trees were carried out at tree nursery of College of Forestry, KAU. The different parameters and their results are furnished in Table 2.

### 4.1.1 Germination percentage

The germination percentage of seeds varied significantly between the candidate plus trees (CPTs) from 67.0 to 83.50 per cent (Table 4.1). The treatment CPT-11 exhibited highest germination per cent (83.50) followed by CPT-10 (82.75) and CPT-9 (78.50). The CPT-1 recorded the lowest value of 67.0 per cent.

### 4.1.2 Peak value of germination

No significant variations were found in Peak value of germination. The peak value of germination was highest for CPT-11 (4.00) and the lowest was for CPT-1 (3.77).

### 4.1.3 Mean daily germination

Analysis of variance showed significant variation in mean daily germination, the maximum mean daily germination was obtained by CPT-11(3.34) followed by CPT-10 (3.31) and CPT-9 (3.13) and minimum for CPT-1 (2.67)

### 4.1.4 Germination Value

Significant difference was observed in germination value. The germination value was highest for CPT-11 (16.31) followed by CPT-10 (15.90) and CPT-8 (13.92) and the lowest was for CPT-1 (10.05).

Table 2.Variation in germination parameters of seeds from different candidate plus trees of *Ailanthus triphysa*

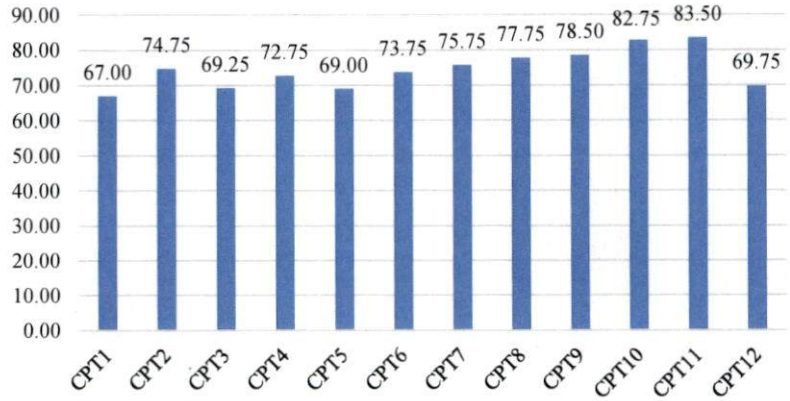
| **Treatments** | **Germination parameters** | | | |
|---|---|---|---|---|
| | **GP** | **MDG** | **PV** | **GV** |
| **CPT1** | $67.00^{d}$ | $2.67^{e}$ | 3.77 | $10.05^{e}$ |
| **CPT2** | $74.75^{bc}$ | $2.99^{bc}$ | 4.35 | $13.05^{de}$ |
| **CPT3** | $69.25^{cd}$ | $2.77^{cde}$ | 3.96 | $11.03^{de}$ |
| **CPT4** | $72.75^{bcd}$ | $2.91^{bcd}$ | 4.17 | $12.22^{cde}$ |
| **CPT5** | $69.00^{cd}$ | $2.75^{de}$ | 4.57 | $12.59^{cd}$ |
| **CPT6** | $73.75^{bc}$ | $2.95^{bcd}$ | 4.19 | $12.36^{cde}$ |
| **CPT7** | $75.75^{b}$ | $3.03^{b}$ | 4.36 | $13.22^{cd}$ |
| **CPT8** | $77.75^{ab}$ | $3.11^{ab}$ | 4.48 | $13.92^{abc}$ |
| **CPT9** | $78.50^{ab}$ | $3.13^{ab}$ | 4.39 | $13.73^{bc}$ |
| **CPT10** | $82.75^{a}$ | $3.31^{a}$ | 4.80 | $15.90^{ab}$ |
| **CPT11** | $83.50^{a}$ | $3.34^{a}$ | 4.88 | $16.31^{a}$ |
| **CPT12** | $69.75^{cd}$ | $2.79^{cde}$ | 3.98 | $11.14^{de}$ |
| **F value** | 6.703** | 6.923** | $2.021^{ns}$ | 4.515** |
| **C.D.** | 5.951 | 0.236 | | 2.509 |

*Values with same superscript along the column are homogenous.*

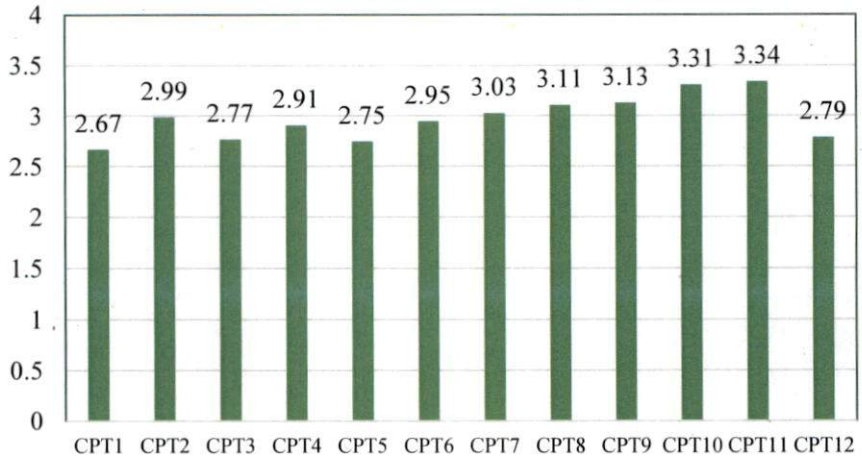
GP = Germination percentage; PVG = Peak value of germination;

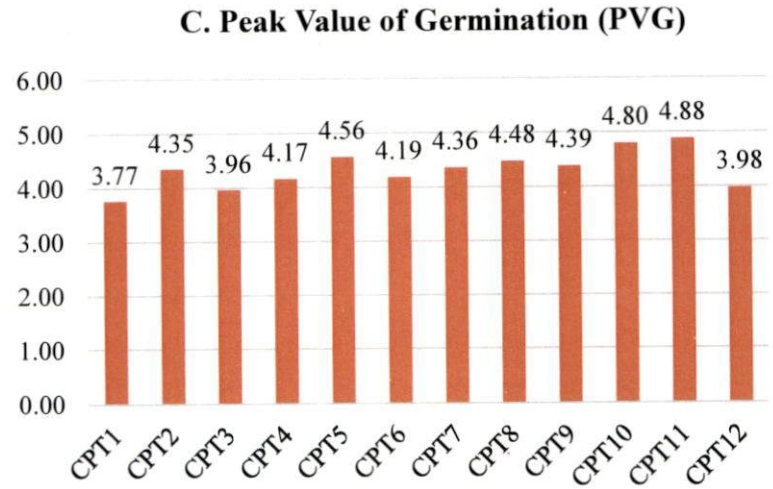
MDG = Mean daily germination; GV = Germination value

**A. Germination percentage (%)**




**B. Mean Daily germination (MDG)**





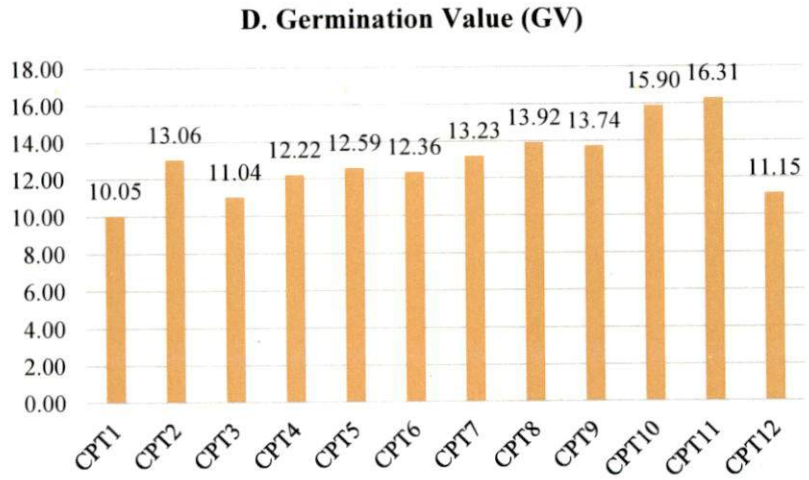




Fig 1. Germination parameters of different candidate plus trees of *Ailanthus triphysa*

## 4.2 NURSERY PERFORMANCE

### 4.2.1 Seedling height

The data on seedling height growth in the nursery is tabulated in (Table 3). The seedling height showed significant difference between the candidate plus trees up to 180 Days after planting (DAP). After the 30 DAP, the highest plant height (42cm) was observed from CPT-6 and minimum (26.66cm) for CPT-1. The height growth was increased consistently from 30 DAP to180 DAP. After 180 DAP of nursery performance, CPT-11 showed the superiority (88.67cm) in height over the all treatments immediately followed by CPT-6, CPT-9, and CPT-10. The poor performance was observed from CPT-5 with seedling height of 76.33cm.

### 4.2.2 Collar diameter

The collar diameter of the CPTs showed significant variation within the progenies of candidate plus trees (Table 4). After the 30 DAP, CPT-3 showed better diameter of (2.47mm) and lowest (1.14mm) diameter. After 60 DAP the collar diameter of all CPTs showed superior growth except CPT-12, CPT-2 and CPT-5. After 180 DAP, collar diameter of CPT-3 was maximum (7.44mm) and minimum for CPT-12 (4.90mm). The CPT-11, CPT-10, CPT-9 also produced better collar diameter after six month of transplanting.

Table 3.Seedling height (cm) of different candidate plus trees of *Ailanthus triphysa* in the nursery.

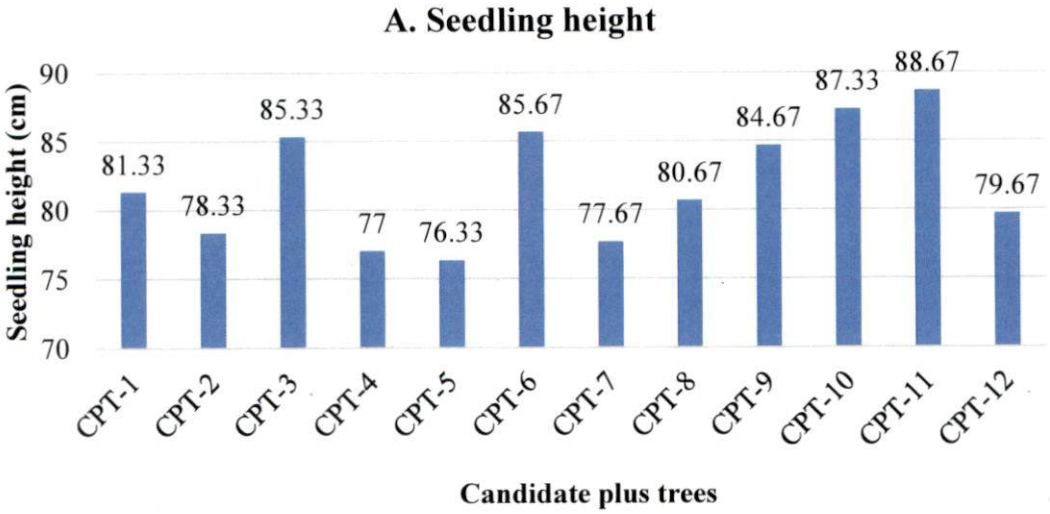
| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | $26.66^{e}$ | $31.00^{d}$ | $41.00^{h}$ | $53.66^{g}$ | $63.33^{f}$ | $81.33^{d}$ |
| **CPT-2** | $27.00^{de}$ | $32.00^{d}$ | $42.00^{gh}$ | $48.00^{h}$ | $59.67^{g}$ | $78.33^{efg}$ |
| **CPT-3** | $34.66^{bc}$ | $46.00^{bc}$ | $57.00^{d}$ | $70.00^{d}$ | $81.00^{b}$ | $85.33^{bc}$ |
| **CPT-4** | $33.00^{bcde}$ | $42.00^{c}$ | $52.00^{e}$ | $65.00^{e}$ | $71.00^{d}$ | $77.00^{g}$ |
| **CPT-5** | $30.00^{cde}$ | $30.33^{d}$ | $41.00^{h}$ | $54.33^{g}$ | $68.67^{e}$ | $76.33^{g}$ |
| **CPT-6** | $42.00^{a}$ | $51.00^{b}$ | $63.00^{b}$ | $76.00^{b}$ | $80.33^{b}$ | $85.67^{bc}$ |
| **CPT-7** | $38.33^{ab}$ | $47.00^{bc}$ | $57.00^{d}$ | $68.33^{d}$ | $74.00^{c}$ | $77.67^{fg}$ |
| **CPT-8** | $29.66^{cde}$ | $34.00^{d}$ | $45.00^{f}$ | $58.00^{f}$ | $64.33^{f}$ | $80.67^{de}$ |
| **CPT-9** | $38.00^{ab}$ | $42.66^{c}$ | $61.00^{c}$ | $73.00^{c}$ | $79.33^{b}$ | $84.67^{c}$ |
| **CPT-10** | $38.00^{ab}$ | $51.00^{b}$ | $61.00^{c}$ | $73.00^{c}$ | $80.33^{b}$ | $87.33^{ab}$ |
| **CPT-11** | $38.33^{ab}$ | $58.00^{a}$ | $68.00^{a}$ | $81.00^{a}$ | $83.00^{a}$ | $88.67^{a}$ |
| **CPT-12** | $33.66^{bcd}$ | $33.00^{d}$ | $43.00^{g}$ | $55.33^{g}$ | $63.33^{g}$ | $79.67^{def}$ |
| **F value** | 4.50** | 20.821** | 230.6** | 277.013** | 184.468** | 22.994** |
| C.D. | 6.886 | 6.007 | 1.895 | 1.853 | 1.671 | 1.853 |

*Values with same superscript along the column are homogenou*

Table 4.Collar diameter (mm), of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | $1.84^{c}$ | $2.82^{a}$ | $3.52^{ab}$ | $4.87^{a}$ | $5.53^{ab}$ | $6.38^{b}$ |
| **CPT-2** | $1.14^{e}$ | $1.74^{b}$ | $2.46^{c}$ | $3.27^{d}$ | $4.27^{de}$ | $5.26^{de}$ |
| **CPT-3** | $2.47^{a}$ | $2.69^{a}$ | $3.20^{ab}$ | $4.75^{ab}$ | $5.44^{ab}$ | $7.44^{a}$ |
| **CPT-4** | $1.85^{c}$ | $2.50^{a}$ | $3.15^{b}$ | $3.89^{c}$ | $4.58^{d}$ | $5.35^{d}$ |
| **CPT-5** | $1.14^{e}$ | $1.42^{b}$ | $2.49^{c}$ | $3.51^{cd}$ | $4.42^{de}$ | $5.60^{cd}$ |
| **CPT-6** | $2.30^{ab}$ | $2.79^{a}$ | $3.38^{ab}$ | $4.62^{ab}$ | $5.42^{ab}$ | $6.44^{b}$ |
| **CPT-7** | $1.42^{d}$ | $2.45^{a}$ | $3.26^{ab}$ | $4.42^{b}$ | $5.56^{ab}$ | $6.73^{b}$ |
| **CPT-8** | $1.55^{d}$ | $2.51^{a}$ | $3.51^{ab}$ | $4.41^{b}$ | $5.58^{ab}$ | $6.48^{b}$ |
| **CPT-9** | $1.90^{c}$ | $2.57^{a}$ | $3.37^{ab}$ | $4.55^{ab}$ | $4.95^{c}$ | $5.79^{c}$ |
| **CPT1-0** | $2.20^{b}$ | $2.49^{a}$ | $3.41^{ab}$ | $4.56^{ab}$ | $5.35^{b}$ | $6.55^{b}$ |
| **CPT1-1** | $2.22^{b}$ | $2.65^{a}$ | $3.59^{a}$ | $4.56^{ab}$ | $5.63^{a}$ | $6.40^{b}$ |
| **CPT-12** | 1.12 | $1.87^{b}$ | $2.10^{c}$ | $3.84^{c}$ | $4.45^{de}$ | $4.90^{e}$ |
| **F value** | 52.837** | 7.893** | 13.144** | 11.892** | 34.931** | 34.23** |
| **C.D.** | 0.196 | 0.468 | 0.396 | 0.436 | 0.262 | 0.366 |

*Values with same superscript along the column are homogenous*



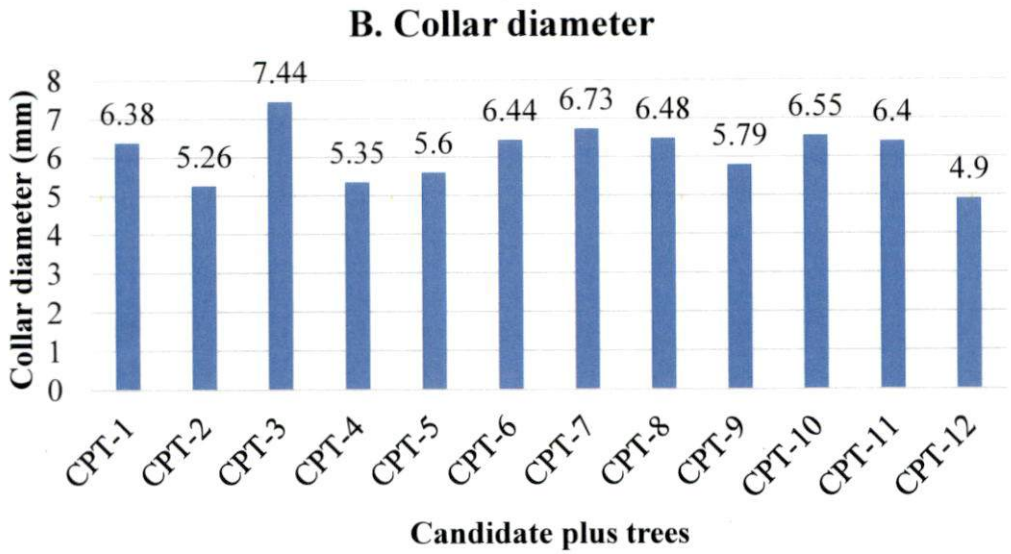




Fig 2. A. Seedling height (cm) and B. collar diameter (mm) of different candidate plus trees of *Ailanthus triphysa* in the nursery at 180 DAP

### 4.2.3 Taproot length

The progenies of all candidate plus trees showed significant difference in root length (Table 5). The root length showed an increasing trend in growth over the period. After the 30 DAP, the CPT-11(15.06cm) and CPT-12(15.26cm) produced highest root length and minimum (10.90cm) was observed for CPT-1. After the 180 DAP, the maximum root length was observed from CPT-11 with 55.33 cm followed by CPT-10, CPT-6, and CPT-12. The minimum length of 22.56 mm was observed from CPT-5. The CPT- 11 and CPT – 10 was consistently shown their superiority over the 180 DAP of growth. The result showed highly significant variation in the root length between the progenies.

### 4.2.4 Number of leaves

The number of leaves of the seedlings of different progenies showed significant variation (Table 6). During the30 DAP, the CPT-11 and CPT-10 produced maximum (27.33) number of leaves. The CPT-1 and CPT – 5 produced lowest number of leaves at the 30 DAP. Till the 120 DAP, the number of leaves of the CPT- 8 perform inferior growth while, during the 150 DAP and 180 DAP, the growth was increased exponentially. After the 180 DAP, the maximum number of leaves (123.66) was produced by CPT- 11 followed by CPT-10, CPT-9 and CPT- 7. The inferior (88.00) in case of number of leaves was CPT -2.

Table 5.Taproot length (cm) of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | $10.90^{f}$ | $15.60^{efg}$ | $16.51^{ef}$ | $25.13^{bc}$ | $29.23^{bc}$ | $32.60^{ef}$ |
| **CPT-2** | $12.76^{cde}$ | $16.60^{defg}$ | $16.51^{ef}$ | $23.81^{cd}$ | $28.53^{bc}$ | $33.33^{ef}$ |
| **CPT-3** | $12.30^{cdef}$ | $14.46^{g}$ | $17.56^{def}$ | $20.96^{de}$ | $25.06^{c}$ | $29.76^{f}$ |
| **CPT-4** | $13.46^{bc}$ | $16.86^{cdef}$ | $21.83^{bcd}$ | $26.23^{abc}$ | $31.56^{b}$ | $35.66^{e}$ |
| **CPT-5** | $11.66^{ef}$ | $14.66^{fg}$ | $16.10^{ef}$ | $17.53^{e}$ | $19.16^{d}$ | $22.56^{g}$ |
| **CPT-6** | $13.56^{bc}$ | $20.16^{a}$ | $16.16^{ef}$ | $26.00^{bc}$ | $31.63^{b}$ | $53.43^{ab}$ |
| **CPT-7** | $13.26^{bcd}$ | $20.56^{a}$ | $24.33^{abc}$ | $26.43^{abc}$ | $31.86^{b}$ | $48.36^{bcd}$ |
| **CPT-8** | $11.96^{def}$ | $19.50^{ab}$ | $12.66^{f}$ | $24.30^{cd}$ | $39.00^{a}$ | $47.10^{cd}$ |
| **CPT-9** | $13.63^{bc}$ | $17.66^{bcde}$ | $23.16^{abc}$ | $25.20^{bc}$ | $42.00^{a}$ | $45.83^{d}$ |
| **CPT-10** | $14.43^{ab}$ | $19.00^{abc}$ | $28.16^{a}$ | $29.63^{a}$ | $40.13^{a}$ | $57.00^{a}$ |
| **CPT-11** | $15.06^{a}$ | $18.61^{abcd}$ | $25.50^{ab}$ | $27.00^{abc}$ | $37.50^{a}$ | $55.33^{a}$ |
| **CPT-12** | $15.26^{a}$ | $15.26^{fg}$ | $20.33^{cde}$ | $28.03^{ab}$ | $39.33^{a}$ | $51.66^{abc}$ |
| **F value** | 7.715** | 7.871** | 7.139** | 7.431** | 13.864** | 38.099** |
| **C.D.** | 1.419 | 2.253 | 5.166 | 3.455 | 5.431 | 5.429 |

*Values with same superscript along the column are homogenous*

Table 6.Number of leaves of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| CPT-1 | $21.00^{def}$ | $33.66^{f}$ | $41.66^{f}$ | $58.00^{e}$ | $74.00^{e}$ | $94.66^{e}$ |
| CPT-2 | $21.00^{def}$ | $35.33^{ef}$ | $52.00^{d}$ | $66.66^{d}$ | $73.00^{e}$ | $88.00^{f}$ |
| CPT-3 | $22.33^{bcde}$ | $37.33^{de}$ | $55.33^{c}$ | $82.66^{ab}$ | $87.66^{cd}$ | $103.33^{cd}$ |
| CPT-4 | $23.33^{bcd}$ | $38.00^{cd}$ | $61.00^{b}$ | $77.00^{bc}$ | $97.00^{ab}$ | $103.66^{cd}$ |
| CPT-5 | $19.66^{ef}$ | $35.00^{ef}$ | $46.33^{e}$ | $68.00^{d}$ | $82.33^{d}$ | $104.00^{cd}$ |
| CPT-6 | $25.66^{ab}$ | $41.00^{ab}$ | $60.33^{b}$ | $84.00^{a}$ | $94.00^{bc}$ | $99.33^{de}$ |
| CPT-7 | $22.00^{cdef}$ | $43.00^{a}$ | $62.00^{b}$ | $88.00^{a}$ | $96.00^{b}$ | $115.33^{b}$ |
| CPT-8 | $21.00^{def}$ | $35.00^{ef}$ | $53.00^{d}$ | $58.00^{e}$ | $96.00^{b}$ | $106.00^{c}$ |
| CPT-9 | $25.33^{abc}$ | $40.33^{bc}$ | $60.00^{b}$ | $73.00^{cd}$ | $90.66^{bc}$ | $107.00^{c}$ |
| CPT-10 | $27.00^{a}$ | $42.00^{ab}$ | $61.33^{b}$ | $76.00^{bc}$ | $96.33^{b}$ | $114.66^{b}$ |
| CPT-11 | $27.33^{a}$ | $43.33^{a}$ | $67.00^{a}$ | $87.33^{a}$ | $103.00^{a}$ | $123.66^{a}$ |
| CPT-12 | $18.66^{f}$ | $26.00^{g}$ | $39.00^{g}$ | $57.66^{e}$ | $73.66^{e}$ | $96.33^{e}$ |
| F value | 6.007** | 35.72** | 148.057** | 23.67** | 22.362** | 23.354** |
| C.D. | 3.437 | 2.43 | 2.114 | 6.857 | 6.486 | 5.967 |

*Values with same superscript along the column are homogenous*

### 4.2.5 Number of leaflets

The observed candidate plus trees showed significant difference in number of leaflets (Table 7). After 30 DAP, the CPT-10 (7.66) and CPT-11(8.66) produced maximum number of leaves and CPT-1(5.33), CPT-2 (5.66) and CPT-12 (5.66) was of lowest number of leaflets. After the 120 DAP, the CPT-6 showed maximum number of leaflets (17.66) and lowest (13.33) from CPT-3 and CPT-12. After 180 DAP superiority in number of leaflets (47.00) was observed from CPT-11 and CPT10 (47.66). Followed by CPT-8 and CPT-9 was produced acceptable number of leaflets. The lowest (26.00) production of number of leaves were by CPT-1. In general the CPT-11 and CPT-10 showed consistent superiority in number of leaflets also throughout the 180 DAP of the growth in the nursery.

### 4.2.6 Number of secondary roots

The number of secondary roots showed significant difference within the candidate plus trees (Table 8). From30 DAP, the CPT-11 shows superiority in number of secondary roots with initial value of (16.00) and minimum (7.00) for CPT-7, which also exhibited a good performance from 120 DAP to fifth month of transplanting. The CPT-4 showed better growth from first (13.66) to 60 DAP (24.66), then the growth was reduced with respect to other progenies. After the 180 DAP the CPT-11 shows the maximum mean value for number of secondary roots (105.66), followed by CPT-10, CPT-9, CPT-12. The CPT-1 was inferior after 180 DAP with mean value of (75.00).

Table 7. Number of leaflets of different candidate plus trees of *Ailanthus triphysa* in the nursery

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | 5.33$^{c}$ | 7.66$^{e}$ | 9.00$^{e}$ | 13.66$^{de}$ | 15.66$^{e}$ | 26.00$^{g}$ |
| **CPT-2** | 5.66$^{c}$ | 7.66$^{e}$ | 9.33$^{de}$ | 14.33$^{de}$ | 16.33$^{e}$ | 35.66$^{f}$ |
| **CPT-3** | 6.66$^{bc}$ | 8.66$^{de}$ | 10.33$^{cde}$ | 13.33$^{e}$ | 20.66$^{d}$ | 36.66$^{def}$ |
| **CPT-4** | 5.66$^{c}$ | 8.66$^{de}$ | 10.00$^{cde}$ | 15.00$^{cd}$ | 21.66$^{cd}$ | 40.00$^{cde}$ |
| **CPT-5** | 6.33$^{bc}$ | 11.33$^{a}$ | 10.00$^{cde}$ | 14.33$^{de}$ | 21.00$^{d}$ | 35.66$^{f}$ |
| **CPT-6** | 6.00$^{c}$ | 10.00$^{abcd}$ | 10.66$^{bcd}$ | 17.66$^{a}$ | 25.66$^{ab}$ | 36.00$^{ef}$ |
| **CPT-7** | 5.33$^{c}$ | 10.33$^{abc}$ | 11.00$^{bc}$ | 15.00$^{cd}$ | 26.33$^{ab}$ | 40.33$^{cd}$ |
| **CPT-8** | 6.00$^{c}$ | 9.00$^{cde}$ | 9.66$^{cde}$ | 16.00$^{bc}$ | 26.00$^{ab}$ | 43.66$^{abc}$ |
| **CPT-9** | 6.66$^{bc}$ | 9.33$^{bcd}$ | 10.33$^{cde}$ | 15.00$^{cd}$ | 24.33$^{bc}$ | 44.66$^{ab}$ |
| **CPT-10** | 7.66$^{ab}$ | 10.66$^{ab}$ | 12.00$^{ab}$ | 16.33$^{abc}$ | 26.00$^{ab}$ | 47.66$^{a}$ |
| **CPT-11** | 8.66$^{a}$ | 11.33$^{a}$ | 12.66$^{a}$ | 17.00$^{ab}$ | 27.33$^{a}$ | 47.00$^{a}$ |
| **CPT-12** | 5.66$^{c}$ | 9.66$^{bcd}$ | 10.00$^{cde}$ | 13.33$^{e}$ | 26.33$^{ab}$ | 41.00$^{bc}$ |
| **F value** | 3.854** | 6.114** | 5.011** | 7.724** | 18.706** | 17.017** |
| **C.D.** | 1.495 | 1.495 | 1.384 | 1.495 | 2.725 | 4.303 |

*Values with same superscript along the column are homogenous*

Table 8. Number of secondary roots of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | $12.66^{cd}$ | $16.00^{c}$ | $28.00^{ef}$ | $43.00^{g}$ | $57.33^{g}$ | $75.00^{e}$ |
| **CPT-2** | $12.00^{cd}$ | $19.00^{bc}$ | $27.33^{ef}$ | $45.00^{fg}$ | $55.33^{h}$ | $78.00^{e}$ |
| **CPT-3** | $13.33^{c}$ | $18.33^{bc}$ | $26.00^{f}$ | $51.66^{de}$ | $75.00^{c}$ | $86.66^{d}$ |
| **CPT-4** | $13.66^{bc}$ | $24.66^{ab}$ | $30.33^{de}$ | $56.00^{bcd}$ | $70.33^{e}$ | $91.00^{cd}$ |
| **CPT-5** | $13.33^{c}$ | $23.00^{abc}$ | $33.00^{bcd}$ | $51.66^{de}$ | $66.66^{f}$ | $78.33^{e}$ |
| **CPT-6** | $13.00^{cd}$ | $22.66^{abc}$ | $42.66^{a}$ | $48.33^{ef}$ | $77.66^{b}$ | $91.00^{cd}$ |
| **CPT-7** | $11.00^{d}$ | $28.66^{a}$ | $43.66^{a}$ | $57.33^{bc}$ | $75.00^{c}$ | $88.00^{cd}$ |
| **CPT-8** | $12.66^{cd}$ | $24.00^{ab}$ | $36.33^{b}$ | $60.33^{ab}$ | $71.00^{e}$ | $92.33^{bc}$ |
| **CPT-9** | $12.00^{cd}$ | $22.00^{abc}$ | $32.66^{cd}$ | $59.66^{ab}$ | $76.00^{bc}$ | $97.00^{b}$ |
| **CPT-10** | $16.00^{a}$ | $29.00^{a}$ | $35.66^{bc}$ | $53.00^{cd}$ | $86.33^{a}$ | $105.00^{a}$ |
| **CPT-11** | $16.00^{a}$ | $28.66^{a}$ | $45.66^{a}$ | $64.00^{a}$ | $88.00^{a}$ | $105.66^{a}$ |
| **CPT-12** | $15.66^{ab}$ | $25.00^{ab}$ | $30.00^{de}$ | $57.33^{bc}$ | $73.00^{d}$ | $96.33^{b}$ |
| **F value** | 4.216** | 3.04* | 30.951** | 17.044** | 214.521** | 36.756** |
| **C.D.** | 2.347 | 7.069 | 3.518 | 4.521 | 1.957 | 4.811 |

*Values with same superscript along the column are homogenous*

### 4.2.7 Number of tertiary roots

Analysis of variance revealed significant difference in number of tertiary roots between different candidate plus trees at 5% up to 60 DAP and 1% from 120 DAP (Table 9). After the 30 DAP, the CPT-12 produced higher (12.33) number of tertiary roots and the minimum for CPT-1(8.00). From the 150 DAP, the CPT-4 recorded increased number of tertiary roots. After the 180 DAP, CPT-11 was the superior over all the candidate plus trees with mean value of 197.33, and CPT-10.CPP-9, CPT-9 were also produce better number of secondary roots. The CPT-1 was the inferior among the all treatments with mean value of 173. The CPT-11 and CPT-10 maintained their superiority throughout 180 DAP.

### 4.2.8 Fresh weight of shoot

The fresh weight of shoot among the selected candidate plus trees was significantly different over 180 DAP (Table 10). During the 30 DAP, the CPT-11 showed the maximum fresh weight (8.58 g) of shoots and the minimum for CPT-1(5.08 g). After the 180 DAP, the CPT-11 exhibited highest fresh weight (24.57 g) of shoots followed by CPT-12, CPT-10, and CPT-9. The lowest value (15.08) was observed from CPT-1.

Table 9. Number of tertiary roots of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| CPT-1 | $8.00^{b}$ | $36.00^{cd}$ | $68.33^{e}$ | $92.00^{de}$ | $124.66^{d}$ | $173.00^{f}$ |
| CPT-2 | $10.00^{ab}$ | $34.00^{d}$ | $65.66^{e}$ | $91.66^{de}$ | $125.00^{d}$ | $175.00^{ef}$ |
| CPT-3 | $8.00^{b}$ | $41.33^{bcd}$ | $82.66^{cd}$ | $98.66^{c}$ | $152.33^{bc}$ | $189.00^{bc}$ |
| CPT-4 | $9.66^{ab}$ | $54.00^{abcd}$ | $75.33^{de}$ | $87.33^{e}$ | $156.00^{abc}$ | $195.66^{ab}$ |
| CPT-5 | $8.66^{b}$ | $66.33^{a}$ | $82.33^{cd}$ | $98.66^{c}$ | $150.66^{7c}$ | $184.33^{cd}$ |
| CPT-6 | $10.00^{ab}$ | $46.66^{abcd}$ | $96.00^{ab}$ | $117.33^{a}$ | $150.33^{c}$ | $184.66^{cd}$ |
| CPT-7 | $8.00^{b}$ | $63.66^{ab}$ | $86.66^{bc}$ | $104.00^{b}$ | $151.66^{bc}$ | $181.00^{de}$ |
| CPT-8 | $12.00^{a}$ | $67.33^{a}$ | $91.33^{bc}$ | $100.00^{bc}$ | $151.00^{bc}$ | $187.33^{cd}$ |
| CPT-9 | $12.33^{a}$ | $34.33^{d}$ | $96.66^{ab}$ | $97.33^{c}$ | $162.33^{a}$ | $196.66^{ab}$ |
| CPT-10 | $11.00^{ab}$ | $51.00^{abcd}$ | $105.00^{a}$ | $113.66^{a}$ | $158.33^{abc}$ | $196.66^{ab}$ |
| CPT-11 | $11.00^{ab}$ | $58.33^{abc}$ | $103.66^{a}$ | $112.33^{a}$ | $159.00^{ab}$ | $197.33^{a}$ |
| CPT-12 | $12.33^{a}$ | $37.33^{cd}$ | $87.66^{bc}$ | $96.33^{cd}$ | $163.66^{a}$ | $186.00^{cd}$ |
| F value | 2.43* | 2.592* | 11.252** | 26.794** | 20.265** | 9.257** |
| C.D. | 3.146 | 23.18 | 11.12 | 5.316 | 8.343 | 8.031 |

*Values with same superscript along the column are homogenous*

Table 10.Fresh weight of shoot (g) of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | $5.08^{c}$ | $9.38^{abcd}$ | $9.71^{d}$ | $10.26^{d}$ | $12.08^{c}$ | $15.08^{h}$ |
| **CPT-2** | $6.38^{bc}$ | $8.37^{de}$ | $9.77^{d}$ | $10.48^{cd}$ | $13.48^{a}$ | $20.40^{fg}$ |
| **CPT-3** | $6.31^{b}$ | $9.79^{abcd}$ | $10.07^{bcd}$ | $10.78^{bcd}$ | $12.34^{bc}$ | $20.21^{g}$ |
| **CPT-4** | $6.10^{b}$ | $10.81^{a}$ | $10.11^{bcd}$ | $11.36^{abc}$ | $13.12^{ab}$ | $20.64^{efg}$ |
| **CPT-5** | $6.06^{bc}$ | $7.47^{e}$ | $9.85^{cd}$ | $10.23^{d}$ | $12.77^{abc}$ | 21.85cde |
| **CPT-6** | $5.74^{bc}$ | $10.48^{ab}$ | $10.58^{abcd}$ | $11.44^{abc}$ | $13.18^{ab}$ | $22.85^{bcd}$ |
| **CPT-7** | $6.18^{b}$ | $8.61^{cde}$ | $11.00^{ab}$ | $11.48^{ab}$ | $13.05^{ab}$ | $22.01^{bcde}$ |
| **CPT-8** | $5.77^{bc}$ | $10.81^{a}$ | $10.87^{abc}$ | $11.08^{abcd}$ | $12.34^{bc}$ | $21.75^{def}$ |
| **CPT-9** | $6.27^{b}$ | $8.72^{bcde}$ | $10.72^{abcd}$ | $11.73^{ab}$ | $12.05^{c}$ | $23.27^{abc}$ |
| **CPT1-0** | $8.17^{a}$ | $10.25^{abc}$ | $10.92^{ab}$ | $11.88^{a}$ | $13.64^{a}$ | $23.08^{bcd}$ |
| **CPT-11** | $8.58^{a}$ | $10.19^{abc}$ | $11.33^{a}$ | $11.98^{a}$ | $12.82^{abc}$ | $24.57^{a}$ |
| **CPT-12** | $5.84^{bc}$ | $7.17^{e}$ | $9.80^{d}$ | $11.34^{abc}$ | $12.39^{bc}$ | $23.36^{ab}$ |
| **F value** | 8.327** | 4.342** | 2.419* | 3.348** | 2.815* | 24.841** |
| **C.D.** | 1.019 | 1.776 | 1.076 | 0.973 | 0.934 | 1.438 |

*Values with same superscript along the column are homogenous*

### 4.2.9 Dry weight of shoot

The dry weight of shoot showed significant variations of the progenies between the selected candidate plus trees (Table 11). The CPT-11(3.08gm), CPT-10 (3.62gm) and CPT-4 (3.88gm) showed the highest dry shoot weight and lowest (2.11gm) for CPT-7. After the 180 DAP, the highest (14.64gm) dry weight of shoot was observed from CPT-11 followed by CPT-10, CPT-9, and CPT-6. The lowest value (12.28gm) was observed from CPT-1. The dry weight of shoot was in an increasing trend over the period and the CPT-11 and CPT-10 were superior over the all treatments.

### 4.2.10 Fresh weight of root

The differences in fresh weight of roots are tabulated in (Table 12). The CPT-1, CPT-2, CPT-3 were inferior from 30 DAP to the 180 DAP. During the 30 DAP the maximum (3.67gm) fresh weight of shoot was observed from CPT-9, and minimum (2.24gm) for CPT-1. After the 180 DAP, the CPT-11 showed the highest fresh weight of roots (20.97g) followed by CPT-7(20.73g) CPT-9 (20.52g) CPT-10 (20.38g) respectively. The lowest fresh weight of root (17.51g) was observed from CPT-1 while the superiority in the fresh root weight was maintained by CPT-11, CPT-10 and CPT-9 throughout the period of growth in the nursery.

Table 11.Dry weight of shoot (g) of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | $2.64^{bcde}$ | $6.56^{c}$ | $7.19^{de}$ | $9.28^{d}$ | $11.35^{bcd}$ | $12.28^{f}$ |
| **CPT-2** | $2.48^{bcde}$ | $6.55^{c}$ | $7.57^{d}$ | $9.44^{d}$ | $11.29^{bcd}$ | $12.83^{def}$ |
| **CPT-3** | $2.50^{bcde}$ | $6.77^{bc}$ | $8.72^{ab}$ | $10.27^{bc}$ | $11.92^{abc}$ | $13.64^{bc}$ |
| **CPT-4** | $2.88^{abcd}$ | $6.82^{bc}$ | $8.43^{abc}$ | $10.44^{abc}$ | $11.86^{abc}$ | $13.33^{bcd}$ |
| **CPT-5** | $3.20^{ab}$ | $7.04^{bc}$ | $8.51^{ab}$ | $10.18^{c}$ | $11.95^{ab}$ | $13.18^{bcde}$ |
| **CPT-6** | $2.66^{bcde}$ | $6.70^{bc}$ | $8.71^{ab}$ | $10.69^{a}$ | $11.47^{bcd}$ | $13.82^{bc}$ |
| **CPT-7** | $2.11^{e}$ | $6.65^{bc}$ | $8.32^{bc}$ | $10.15^{c}$ | $12.30^{a}$ | $13.11^{cde}$ |
| **CPT-8** | $2.22^{de}$ | $8.58^{a}$ | $6.94^{e}$ | $10.46^{abc}$ | $11.13^{cd}$ | $12.56^{ef}$ |
| **CPT-9** | $2.35^{cde}$ | $7.17^{b}$ | $8.69^{ab}$ | $10.47^{abc}$ | $11.06^{d}$ | $13.93^{ab}$ |
| **CPT-10** | $3.62^{a}$ | $6.84^{bc}$ | $8.85^{a}$ | $10.53^{ab}$ | $12.54^{a}$ | $13.52^{bcd}$ |
| **CPT-11** | $3.08^{abc}$ | $6.75^{bc}$ | $8.73^{ab}$ | $10.62^{a}$ | $12.46^{a}$ | $14.64^{a}$ |
| **CPT-12** | $2.55^{bcde}$ | $6.63^{bc}$ | $8.05^{c}$ | $9.167^{d}$ | $11.39^{bcd}$ | $13.71^{bc}$ |
| **F value** | 2.765* | 8.65** | 18.58** | 21.448** | 3.628** | 6.125** |
| **C.D.** | 0.771 | 0.632 | 0.443 | 0.341 | 0.8 | 0.765 |

*Values with same superscript along the column are homogenous*

Table 12.Fresh weight of root (g) of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | $2.24^{d}$ | $6.44^{de}$ | $9.83^{cd}$ | $10.73^{b}$ | $13.43^{c}$ | $17.51^{g}$ |
| **CPT-2** | $2.43^{cd}$ | $6.18^{e}$ | $9.40^{d}$ | $10.37^{b}$ | $13.61^{c}$ | $18.63^{efg}$ |
| **CPT-3** | $2.89^{bc}$ | $7.77^{abc}$ | $10.41^{abc}$ | $12.06^{a}$ | $15.02^{a}$ | $19.34^{cde}$ |
| **CPT-4** | $2.76^{bcd}$ | $7.76^{abc}$ | $10.19^{bcd}$ | $12.28^{a}$ | $15.20^{a}$ | $18.77^{def}$ |
| **CPT-5** | $2.82^{bc}$ | $8.34^{a}$ | $10.27^{abcd}$ | $11.88^{a}$ | $14.86^{ab}$ | $19.38^{cde}$ |
| **CPT-6** | $3.27^{ab}$ | $7.21^{ab}$ | $10.30^{abcd}$ | $12.08^{a}$ | $14.99^{ab}$ | $19.88^{abcd}$ |
| **CPT-7** | $3.55^{a}$ | $7.36^{bc}$ | $10.15^{cd}$ | $11.95^{a}$ | $15.32^{a}$ | $20.73^{ab}$ |
| **CPT-8** | $2.74^{bcd}$ | $7.38^{bc}$ | $9.93^{cd}$ | $10.73^{b}$ | $13.85^{c}$ | $19.58^{bcde}$ |
| **CPT-9** | $3.67^{a}$ | $8.18^{ab}$ | $11.14^{a}$ | $12.55^{a}$ | $15.24^{a}$ | $20.52^{abc}$ |
| **CPT-10** | $3.47^{a}$ | $8.05^{ab}$ | $11.09^{ab}$ | $12.56^{a}$ | $15.36^{a}$ | $20.38^{abc}$ |
| **CPT-11** | $3.53^{a}$ | $8.54^{a}$ | $10.37^{abc}$ | $11.98^{a}$ | $15.65^{a}$ | $20.97^{a}$ |
| **CPT-12** | $2.58^{cd}$ | $7.50^{bc}$ | $9.71^{cd}$ | $10.84^{b}$ | $14.07^{bc}$ | $18.02^{fg}$ |
| **F value** | 6.481** | 6.254** | 2.592* | 7.061** | 5.453** | 7.168** |
| **C.D.** | 0.558 | 0.842 | 0.926 | 0.856 | 0.96 | 1.194 |

*Values with same superscript along the column are homogenous*

### 4.2.11 Dry weight of root

Analysis of variance revealed significant difference in dry weight of root due to different candidate plus trees over time (Table 13). The dry weight of root showed an increasing trend in the whole period of nursery growth. After the 30 DAP, CPT-10 showed the maximum (2.52g) and lowest (1.35g) for CPT-1. After 60 DAP, the CPT-8 decreased (5.62g) its dry weight as compared to all other progenies. After the 18 DAP, the highest dry weight of root (15.137g) was observed from CPT-11. Similar higher values were observed from CPT-10, CPT-9 and CPT-6. The lowest value (10.23g) was observed from CPT-1. The CPT-11, CPT-10 and CPT-9 showed consistent superior growth over the period of the nursery experiment.

### 4.2.12 Root- Shoot length ratio

Significant difference in the shoot- root length ratio of the progenies of candidate plus trees were observed (Table 14). After the 30 DAP, there is no significant difference in root- shoot ratio. After the 60 DAP, CPT-8 was produced high value of 0.57 and the minimum for CPT- 3 (0.31). At 90 DAP, the maximum value observed from CPT-12 (0.47) and minimum for CPT- 6 (0.26). At 120 DAP the maximum of 0.51 was observed from CPT-12 followed by CPT- 2(0.49). At 180 DAP the highest value (0.60) was observed from CPT-12 followed by CPT- 3 (0.29)

Table 13.Dry weight of root (g) of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | 1.35$^{c}$ | 4.61$^{e}$ | 7.48$^{c}$ | 8.28$^{c}$ | 9.28$^{e}$ | 10.23$^{f}$ |
| **CPT-2** | 1.50$^{c}$ | 5.23$^{de}$ | 7.33$^{c}$ | 8.26$^{c}$ | 10.26$^{cd}$ | 12.55$^{ef}$ |
| **CPT-3** | 1.49$^{c}$ | 6.35$^{ab}$ | 8.28$^{ab}$ | 9.50$^{ab}$ | 10.83$^{abc}$ | 13.77$^{bcd}$ |
| **CPT-4** | 1.52$^{c}$ | 5.99$^{bc}$ | 8.15$^{ab}$ | 9.35$^{b}$ | 10.35$^{bcd}$ | 13.82$^{bc}$ |
| **CPT-5** | 1.52$^{c}$ | 6.42$^{ab}$ | 7.89$^{bc}$ | 9.60$^{ab}$ | 10.93$^{abc}$ | 14.10$^{abc}$ |
| **CPT-6** | 1.50$^{c}$ | 6.71$^{a}$ | 8.68$^{a}$ | 10.00$^{a}$ | 11.67$^{a}$ | 14.36$^{ab}$ |
| **CPT-7** | 1.53$^{c}$ | 5.92$^{bc}$ | 7.75$^{bc}$ | 9.73$^{ab}$ | 11.06$^{abc}$ | 14.32$^{ab}$ |
| **CPT-8** | 1.56$^{c}$ | 5.62$^{cd}$ | 7.67$^{bc}$ | 8.48$^{c}$ | 10.48$^{bcd}$ | 13.08$^{cde}$ |
| **CPT-9** | 1.97$^{b}$ | 6.76$^{a}$ | 8.57$^{a}$ | 9.55$^{ab}$ | 11.22$^{ab}$ | 14.17$^{abc}$ |
| **CPT-10** | 2.52$^{a}$ | 6.76$^{a}$ | 8.74$^{a}$ | 9.55$^{ab}$ | 11.22$^{ab}$ | 14.84$^{ab}$ |
| **CPT-11** | 2.38$^{a}$ | 6.46$^{ab}$ | 8.24$^{ab}$ | 9.50$^{ab}$ | 11.50$^{a}$ | 15.13$^{a}$ |
| **CPT-12** | 1.39$^{c}$ | 5.07$^{de}$ | 7.38$^{c}$ | 8.50$^{c}$ | 9.83$^{de}$ | 12.63$^{def}$ |
| **F value** | 26.388** | 11.295** | 5.398** | 11.616** | 5.553** | 2.807** |
| **C.D.** | 0.222 | 0.629 | 0.637 | 0.537 | 0.876 | 3.189 |

*Values with same superscript along the column are homogenous*

Table 14.Root - Shoot length ratio of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | 0.41 | $0.50^{bc}$ | $0.40^{ab}$ | $0.47^{ab}$ | $0.44^{cde}$ | $0.39^{ef}$ |
| **CPT-2** | 0.47 | $0.51^{ab}$ | $0.39^{ab}$ | $0.49^{a}$ | $0.45^{cd}$ | $0.42^{ef}$ |
| **CPT-3** | 0.35 | $0.31^{f}$ | $0.30^{bcd}$ | $0.30^{e}$ | $0.29^{gh}$ | $0.29^{g}$ |
| **CPT-4** | 0.41 | $0.40^{de}$ | $0.42^{a}$ | $0.40^{c}$ | $0.39^{def}$ | $0.37^{f}$ |
| **CPT-5** | 0.39 | $0.48^{bc}$ | $0.39^{ab}$ | $0.32^{e}$ | $0.28^{h}$ | $0.26^{g}$ |
| **CPT-6** | 0.32 | $0.39^{de}$ | $0.26^{d}$ | $0.34^{de}$ | $0.35^{fg}$ | $0.50^{bc}$ |
| **CPT-7** | 0.34 | $0.44^{cde}$ | $0.42^{a}$ | $0.38^{cd}$ | $0.38^{ef}$ | $0.49^{cd}$ |
| **CPT-8** | 0.41 | $0.57^{a}$ | $0.28^{cd}$ | $0.42^{bc}$ | $0.54^{ab}$ | $0.53^{bc}$ |
| **CPT-9** | 0.36 | $0.43^{cde}$ | $0.38^{ab}$ | $0.34^{de}$ | $0.48^{bc}$ | $0.44^{de}$ |
| **CPT-10** | 0.38 | $0.37^{ef}$ | $0.46^{a}$ | $0.40^{c}$ | $0.45^{cd}$ | $0.55^{ab}$ |
| **CPT-11** | 0.39 | $0.32^{f}$ | $0.37^{abc}$ | $0.33^{de}$ | $0.39^{def}$ | $0.50^{bc}$ |
| **CPT-12** | 0.46 | $0.46^{bcd}$ | $0.47^{a}$ | $0.51^{a}$ | $0.57^{a}$ | $0.60^{a}$ |
| **F value** | $2.090^{ns}$ | 10.161** | 3.944** | 13.836** | 15.303** | 30.903** |
| **C.D.** | | 0.073 | 0.099 | 0.055 | 0.066 | 0.054 |

*Values with same superscript along the column are homogenous*

### 4.2.13 Root- Shoot biomass ratio

The root-shoot biomass ratio of seedlings are tabulated in (Table 15). The data showed significant difference at 30, 60 and 180 DAP. From 90 DAP to 150 DAP the root- shoot biomass was not significantly different. At 30 DAP the maximum value (0.58) was exhibited from CPT-9 and minimum (0.32) for CPT-2. At 60 DAP the highest value (1.11) from CPT- 5 and minimum (0.68) for CPT- 8. At 180 DAP the highest value (1.16) was observed from CPT-1 and followed by CPT- 3(0.96).

Table 15.Root – shoot biomass ratio of different candidate plus trees of *Ailanthus triphysa* in the nursery.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT-1** | $0.44^{bc}$ | $0.72^{de}$ | 1.01 | 1.04 | 1.11 | $1.16^{a}$ |
| **CPT-2** | $0.38^{c}$ | $0.74^{de}$ | 0.96 | 0.98 | 1.00 | $0.91^{bcd}$ |
| **CPT-3** | $0.47^{abc}$ | $0.81^{cde}$ | 1.04 | 1.12 | 1.21 | $0.96^{b}$ |
| **CPT-4** | $0.46^{abc}$ | $0.71^{de}$ | 1.01 | 1.087 | 1.16 | $0.91^{bcd}$ |
| **CPT-5** | $0.46^{abc}$ | $1.11^{a}$ | 1.04 | 1.16 | 1.16 | $0.89^{bcd}$ |
| **CPT-6** | $0.57^{ab}$ | $0.69^{e}$ | 0.97 | 1.06 | 1.13 | $0.87^{cd}$ |
| **CPT-7** | $0.59^{a}$ | $0.86^{cd}$ | 0.92 | 1.04 | 1.17 | $0.94^{bc}$ |
| **CPT-8** | $0.47^{abc}$ | $0.68^{e}$ | 0.91 | 0.97 | 1.12 | $0.90^{bcd}$ |
| **CPT-9** | $0.58^{a}$ | $0.93^{bc}$ | 1.04 | 1.07 | 1.26 | $0.88^{bcd}$ |
| **CPT-10** | $0.42^{c}$ | $0.78^{cde}$ | 1.02 | 1.06 | 1.12 | $0.88^{bcd}$ |
| **CPT-11** | $0.41^{c}$ | $0.84^{cde}$ | 0.91 | 1.00 | 1.22 | $0.85^{de}$ |
| **CPT-12** | $0.44^{bc}$ | $1.05^{ab}$ | 0.99 | 0.96 | 0.76 | $0.77^{e}$ |
| **F value** | 2.242* | 6.128** | NS | NS | NS | 9.714** |
| **C.D.** | 0.136 | 0.166 | | | | 0.086 |

*Values with same superscript along the column are homogenous*

## 4.3 FIELD EVALUATION

### 4.3.1 Plant height

The data on plant height of seedlings planted in the field are furnished in (Table 16). The analysis of variance showed significant difference within the plants of the candidate plus trees. At 30DAP, maximum plant height (49.55cm) was observed from CPT-5 and minimum (36.33cm) for CPT-1. At 60 DAP the plant height was varied from 41.22cm to 56.66cm. After 180 DAP the superior plant height (99.00cm) was observed from CPT-11 followed by CPT-9, CPT-10, CPT-2 and CPT-7. The lowest plant height was for CPT-1(82.00cm).

### 4.3.2 Collar diameter

The collar diameter of the selected seedlings are tabulated in (Table 17). It showed an increasing trend from the 30DAP to 180DAP. At 30DAP, the collar diameter varied from 6.96 mm (CPT-1) to 9.80 mm (CPT-11). At 180 DAP, the collar diameter of CPT-11 was increased consistently and attained a maximum of 21.04 mm followed by CPT-7, CPT-8 and CPT-5. The lowest (14.60mm) collar diameter at 180DAP was observed from CPT-6. After 180DAP the CPT-11 was the superior one throughout the field evaluation period.

Table 16.Plant height (cm) of different candidate plus trees of *Ailanthus triphysa* in the Instructional Farm of KAU, Vellanikkara.

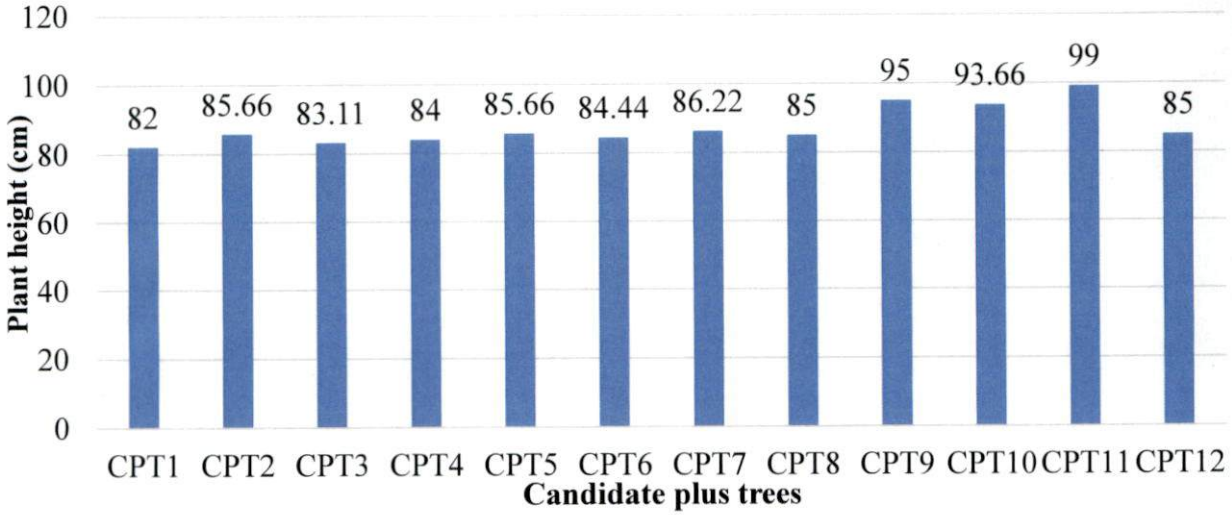
| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT1** | 36.33 | $41.22^{c}$ | $45.11^{c}$ | $50.88^{d}$ | $61.44^{d}$ | $82.00^{b}$ |
| **CPT2** | 47.66 | $54.66^{ab}$ | $59.00^{ab}$ | $66.44^{ab}$ | $75.88^{ab}$ | $85.66^{b}$ |
| **CPT3** | 43.22 | $50.00^{abc}$ | $54.88^{abc}$ | $61.77^{abc}$ | $71.44^{abcd}$ | $83.11^{b}$ |
| **CPT4** | 37.11 | $40.77^{c}$ | $44.88^{c}$ | $53.22^{cd}$ | $62.44^{cd}$ | $84.00^{b}$ |
| **CPT5** | 49.55 | $56.88^{a}$ | $62.66^{a}$ | $70.55^{a}$ | $81.22^{a}$ | $85.66^{b}$ |
| **CPT6** | 44.33 | $49.00^{abc}$ | $53.33^{abc}$ | $61.44^{abcd}$ | $73.77^{abc}$ | $84.44^{b}$ |
| **CPT7** | 48.33 | $53.33^{ab}$ | $59.00^{ab}$ | $67.77^{ab}$ | $78.55^{ab}$ | $86.22^{b}$ |
| **CPT8** | 46.11 | $52.00^{ab}$ | $56.77^{ab}$ | $64.66^{ab}$ | $75.44^{ab}$ | $85.00^{b}$ |
| **CPT9** | 41.22 | $45.88^{bc}$ | $50.77^{bc}$ | $59.11^{bcd}$ | $70.00^{abcd}$ | $95.00^{a}$ |
| **CPT10** | 42.22 | $48.22^{abc}$ | $52.66^{abc}$ | $59.88^{bcd}$ | $68.77^{bcd}$ | $93.66^{a}$ |
| **CPT11** | 46.66 | $51.66^{ab}$ | $55.77^{ab}$ | $63.33^{abc}$ | $73.22^{abc}$ | $99.00^{a}$ |
| **CPT12** | 46.88 | $51.77^{ab}$ | $56.22^{ab}$ | $64.77^{ab}$ | $76.33^{ab}$ | $85.00^{b}$ |
| **F value** | $2.25^{ns}$ | 2.227* | 2.361* | 2.454* | 2.269* | 7.228** |
| **C.D.** | | 9.721 | 10.289 | 10.728 | 11.729 | 5.932 |

*Values with same superscript along the column are homogenous*

Table 17.Collar diameter (mm) of different candidate plus trees of *Ailanthus triphysa* in the Instructional Farm of KAU, Vellanikkara.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT1** | $6.96^{c}$ | $8.50^{b}$ | $10.05^{b}$ | $11.92^{bc}$ | $14.68^{b}$ | $17.60^{b}$ |
| **CPT2** | $8.89^{ab}$ | $9.69^{ab}$ | $10.89^{b}$ | $12.17^{b}$ | $15.12^{b}$ | $18.05^{b}$ |
| **CPT3** | $7.85^{bc}$ | $8.97^{b}$ | $9.97^{b}$ | $12.12^{b}$ | $15.46^{b}$ | $18.53^{b}$ |
| **CPT4** | $8.05^{bc}$ | $9.26^{b}$ | $10.54^{b}$ | $12.35^{b}$ | $14.87^{b}$ | $17.65^{b}$ |
| **CPT5** | $8.64^{ab}$ | $9.78^{ab}$ | $10.80^{b}$ | $12.43^{b}$ | $15.15^{b}$ | $18.35^{b}$ |
| **CPT6** | $7.68^{bc}$ | $8.50^{b}$ | $9.52^{b}$ | $10.32^{c}$ | $11.55^{c}$ | $14.60^{c}$ |
| **CPT7** | $8.93^{ab}$ | $9.82^{ab}$ | $10.65^{b}$ | $12.90^{b}$ | $16.12^{b}$ | $19.15^{ab}$ |
| **CPT8** | $8.38^{b}$ | $9.26^{b}$ | $10.53^{b}$ | $12.23^{b}$ | $15.64^{b}$ | $18.59^{b}$ |
| **CPT9** | $8.11^{bc}$ | $9.05^{b}$ | $10.06^{b}$ | $11.72^{bc}$ | $14.95^{b}$ | $18.29^{b}$ |
| **CPT10** | $8.52^{ab}$ | $9.41^{b}$ | $10.61^{b}$ | $11.91^{bc}$ | $14.98^{b}$ | $18.15^{b}$ |
| **CPT11** | $9.80^{a}$ | $11.15^{a}$ | $13.23^{a}$ | $14.64^{a}$ | $18.08^{a}$ | $21.04^{a}$ |
| **CPT12** | $8.32^{bc}$ | $9.82^{ab}$ | $10.75^{b}$ | $12.14^{b}$ | $15.57^{b}$ | $18.52^{b}$ |
| **F value** | 2.271* | 2.291* | 3.391** | 2.719* | 5.584** | 4.352** |
| **C.D.** | 1.402 | 1.389 | 1.465 | 1.746 | 1.821 | 2.047 |

*Values with same superscript along the column are homogenous*



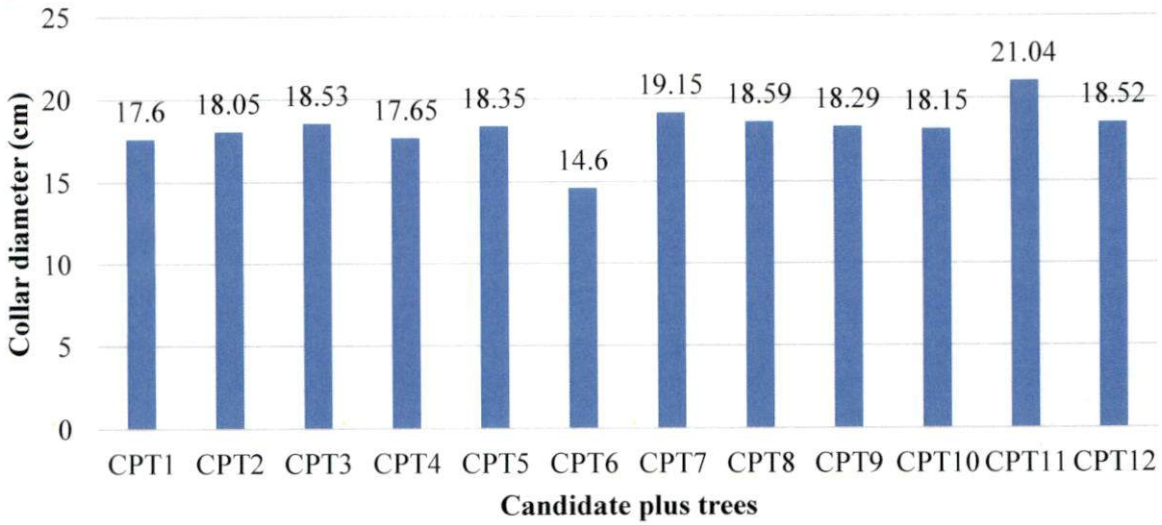




**Fig 3.** Plant height (cm) and collar diameter (mm) of different candidate plus trees of *Ailanthus triphysa* in the field at 180 DAP

### 4.3.3 Number of leaves

The analysis of variance showed significant difference in the number of leaves of the seedlings of the candidate plus trees (Table 18). At 30DAP the highest (11.88) number of leaves showed by CPT-2 and lowest (8.55) was showed by CPT-1. AT 60DAP the number of leaves varied from 13.33 to 9.66.At 90DAP the maximum (15.33) leaves produced by CPT-5 and minimum (11.66) was produced by CPT-1. At 120 DAP the CPT-11 was leading their superiority (17.22) in number of leaves and minimum (13.44) was observed from CPT-1. At 180DAP the maximum number of leaves (23.55) was produced by CPT-12 followed by CPT-8, CPT-11, CPT-5. The lowest (18.77) was observed from CPT-1.

### 4.3.4 Number of leaflets

Number of leaflets was analysed for variation between the different progenies of the candidate plus trees. The results revealed significant difference in total number of leaflets (Table 19). At 30DAP, the maximum number of leaflets (81.22) produced by CPT-11 and minimum (49.33) for CPT-1. At 60 DAP the number of leaflets varied from 108.33 to 43.77. At 120DAP the CPT-11 was superior (197.00) and the inferior one was CPT-1(13.77). At 10 DAP the CPT-11 gives the maximum (369.77) number of leaflets and minimum (212.66) for CPT-1. The CPT-9, CPT-12, CPT-10 were also exhibited a superior growth in terms of total number of leaflets.

Table 18. Number of leaves of different candidate plus trees of *Ailanthus triphysa* in the Instructional Farm of KAU, Vellanikkara.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT1** | $8.55^{e}$ | $9.66^{e}$ | $11.66^{d}$ | $13.44^{e}$ | $16.11^{f}$ | $18.77^{e}$ |
| **CPT2** | $11.88^{a}$ | $13.00^{ab}$ | $15.00^{a}$ | $17.11^{a}$ | $19.66^{ab}$ | $23.55^{a}$ |
| **CPT3** | $9.00^{de}$ | $10.00^{de}$ | $12.33^{cd}$ | $15.33^{bcd}$ | $18.44^{bcd}$ | $22.33^{abc}$ |
| **CPT4** | $8.77^{e}$ | $9.77^{e}$ | $11.88^{cd}$ | $13.88^{de}$ | $16.44^{ef}$ | $20.55^{bcde}$ |
| **CPT5** | $11.11^{ab}$ | $13.33^{a}$ | $15.33^{a}$ | $16.88^{a}$ | $19.44^{ab}$ | $23.22^{a}$ |
| **CPT6** | $10.00^{bcde}$ | $11.11^{cde}$ | $12.44^{cd}$ | $13.88^{de}$ | $16.00^{f}$ | $19.11^{de}$ |
| **CPT7** | $10.77^{abc}$ | $12.44^{abc}$ | $14.44^{ab}$ | $16.44^{ab}$ | $18.88^{abc}$ | $22.66^{ab}$ |
| **CPT8** | $9.77^{bcde}$ | $10.88^{cde}$ | $13.33^{bc}$ | $16.00^{abc}$ | $18.66^{bc}$ | $23.33^{a}$ |
| **CPT9** | $9.55^{cde}$ | $10.66^{de}$ | $13.00^{bcd}$ | $15.77^{abc}$ | $18.88^{abc}$ | $21.55^{abcd}$ |
| **CPT10** | $9.55^{cde}$ | $10.66^{de}$ | $12.66^{cd}$ | $14.88^{cde}$ | $17.11^{def}$ | $20.22^{bcde}$ |
| **CPT11** | $10.33^{bcd}$ | $11.44^{bcd}$ | $14.44^{ab}$ | $17.22^{a}$ | $20.22^{a}$ | $23.22^{a}$ |
| **CPT12** | $9.66^{bcde}$ | $10.88^{cde}$ | $12.88^{cd}$ | $15.00^{bcd}$ | $17.66^{cde}$ | $20.11^{cde}$ |
| **F value** | 3.875** | 5.102** | 5.422** | 6.531** | 8.234** | 4.3** |
| **C.D.** | 1.47 | 1.574 | 1.559 | 1.509 | 1.478 | 2.47 |

*Values with same superscript along the column are homogenous*

Table 19. Total number of leaflets different candidate plus trees of *Ailanthus triphysa* in the Instructional Farm of KAU, Vellanikkara.

| Treatments | 30 DAP | 60DAP | 90DAP | 120DAP | 150DAP | 180DAP |
|---|---|---|---|---|---|---|
| **CPT1** | $49.33^{c}$ | $43.77^{e}$ | $85.88^{d}$ | $139.77^{cd}$ | $147.44^{g}$ | $212.66^{d}$ |
| **CPT2** | $81.00^{a}$ | $91.00^{abc}$ | $126.00^{ab}$ | $171.55^{abcd}$ | $228.88^{abc}$ | $334.55^{a}$ |
| **CPT3** | $66.00^{abc}$ | $73.22^{cd}$ | $102.66^{bcd}$ | $158.22^{abcd}$ | $211.00^{def}$ | $321.22^{abc}$ |
| **CPT4** | $52.22^{c}$ | $62.11^{de}$ | $94.77^{cd}$ | $133.33^{d}$ | $164.66^{fg}$ | $259.66^{cd}$ |
| **CPT5** | $77.66^{a}$ | $93.22^{abc}$ | $126.44^{ab}$ | $154.11^{bcd}$ | $223.77^{cde}$ | $325.88^{ab}$ |
| **CPT6** | $56.22^{bc}$ | $73.66^{cd}$ | $104.00^{abcd}$ | $130.11^{d}$ | $180.00^{efg}$ | $264.11^{bcd}$ |
| **CPT7** | $74.66^{ab}$ | $86.11^{abc}$ | $121.22^{abc}$ | $150.22^{bcd}$ | $226.44^{cde}$ | $310.33^{abc}$ |
| **CPT8** | $75.55^{ab}$ | $81.66^{bcd}$ | $108.66^{abcd}$ | $152.88^{bcd}$ | $212.11^{def}$ | $339.88^{a}$ |
| **CPT9** | $75.77^{ab}$ | $98.00^{ab}$ | $129.55^{a}$ | $197.00^{a}$ | $289.11^{a}$ | $369.77^{a}$ |
| **CPT10** | $77.88^{a}$ | $97.77^{ab}$ | $120.44^{abc}$ | $182.00^{abc}$ | $261.11^{abcd}$ | $344.88^{a}$ |
| **CPT11** | $81.22^{a}$ | $108.33^{a}$ | $123.66^{ab}$ | $188.88^{abc}$ | $281.00^{ab}$ | $370.00^{a}$ |
| **CPT12** | $80.33^{a}$ | $97.88^{ab}$ | $115.33^{abc}$ | $180.66^{abc}$ | $271.88^{abc}$ | $346.66^{a}$ |
| **F value** | 3.023* | 5.413** | 2.383* | 2.351* | 6.167** | 4.97** |
| **C.D.** | 19.855 | 23.063 | 26.668 | 42.721 | 54.128 | 63.369 |

*Values with same superscript along the column are homogenous*

### 4.3.5 Survival Percentage

After 180 DAP, the survival percentage in the field was 98.14 per cent.

### 4.3.6 Number of forking

After the 180 DAP, the phenomenon of forking of the main stem was not prominent in the seedlings of the *Ailanthus triphysa.* The maximum forking observed was only 4 (CPT-6) and the minimum of 1(CPT5).

# DISCUSSION

# DISCUSSION

## 5.1 GERMINATION STUDIES

The results obtained in the research work entitled 'Selection and evaluation of superior planting materials of *Ailanthus triphysa'* are discussed in this chapter. The study was conducted by selecting candidate plus trees (CPT) from the Thrissur district and evaluated the initial growth performance of their progenies in the nursery as well as in the field.

The germination percent varied from 67 per cent to 83.5 per cent. The CPT-11 produced the highest (83.5%) germination percent (Table 2). Similar significant result was also found by Paul (2017) in CPTs *of Ailanthus triphysa* from different seed sources. Indira (1996) reported a germination percent of 69.20 per cent in *Ailanthus triphysa* from different seed sources. The CPT-1 from the Malayoram region showed the lowest (66.5%) germination percent. Rawat *et al.* (2006) in *Pinus wallichiana* and Mahto *et al.* (2006) in *Azadirachta indica* also obtained similar results. Chhaganbhai (2014) also reported the lowest value of 61.81 % from selected plants of *Ailanthus excelsa* from different seed sources. A significant (p= 0.01)positive correlation was found between percent of sound seed and elevational range of seed sources of *Grewia oppositifolia* (Uniyal *et al.*, 2003) and Chhaganbhai (2014) in *Ailanthus excelsa* selections. Significant variations in germination ability of a species among seed samples of different sources have been reported for several species of Central Himalaya (*Quercus* spp.,*Celtis australis, Acer oblongum, Sapindus mukorossi, Desmodium elegans, Alnus nepalensis, Myrica esculenta,* etc.). Causes of such variability might be generally attributed either to the genetic characters of source population (Bewley and Black 1994), or the impact of mother plant environment (Andersson and Milberg 1998; Bhatt *et al.* 2000).

The seeds which germinate rapidly and vigorously under favourable conditions are likely to be capable of producing vigorous seedlings in field conditions, whereas weak or delayed germination is often fatal (Aldhous 1972). Results of the present study strongly support this hypothesis as the selected CPT-11 having higher seed germination also had better field performance. In view of the high heritability of germination percentage, which has been also reported by Khalil (1978), and its significant relationship with early height and collar diameter growth which is maintained up to last month (i.e., after 180 DAP) measurement, there is a good indication that the candidate plus tree, which are superior in seed quality are also superior in growth and survival. The progenies with superior initial growth rates maintain their superiority until a later developmental stage (Khalil 1981). Thus, seed germination characteristics can be under strong genetic control (Isik 1986, Arya *et al* 1995). From this point of view this parameter can be included in the criteria for the selection of superior plus trees. Wani and Ahmed (2013) supported this hypothesis with a significant difference in the field environment with respect to the germination traits of the 12 candidate plus trees of *Ailanthus triphysa* from different seed sources.

Seed dormancy may also influence seed germination, which is controlled by genetic factors (Kumar *et al*., 2007). Shivanna *et al.* (2007) recorded variation in seed germination among different seed sources ranging from 69.61% to 89.20%. Almost same result was obtained from this study. Similarly, seed source variation has also been recorded in *Acacia nilotica* for seed germination from 69.33% to 80.66 % (Chillar *et al.*, 2002). It shows that seed source and individual trees have more influence on seed germination.

The germination value was significantly different and it ranged from 10.05 to 16.31 (Table 2). The highest germination value of (16.314) was exhibited by CPT-11. Paul (2016) also reported similar germination value of 15.91 from the selected candidate plus tree of *Ailanthus triphysa* .CPT-1 showed the poor performance of (10.05). Similar value is also obtained from candidate plus tree of

*Ailanthus triphysa* (Paul, 2017). This is due to the genetic characteristics of the seeds. Germination value which is further an expression of germination energy has been used as an integrated measure of seed quality in *Terminalia ivorensis* by Okoro (1976) and *Pinus kesia* by Costales and Veracion (1978). Provenances with higher germination also had higher germination value.

The mean daily germination ranged from 2.67 to 3.34 and had a significant difference in these parameters (Table 2). Similar results were also reported by Paul (2017) in selections of *Ailanthus triphysa*. The tree with higher germination percent also exhibited higher value of mean daily germination. Among the selected CPTs of *Ailanthus triphysa*, the peak value of the germination was non-significant (Table 2) while Paul (2017) reported a significant difference in peak value of germination. This variation may be attributed to the difference in genetic and nursery condition of the experimented seeds.

Many workers have proved that seeds of a single species when collected from different sources differ in viability, germination and growth (Isik, 1986; Kumar *et al.*, 2007). Shivanna *et al.* (2007) recorded variation in seed germination among different seed sources ranging from 69.61% to 89.20%. Similarly, seed source variation has also been recorded in *Acacia nilotica* for seed germination (69.33–80.66%). It shows that seed source and individual trees have more influence on seed germination. This variation is mainly attributed to genetic and environmental factors which affect the seedlings growth. Similar trend has also been documented among seed sources for vigour indices in many tropical species like *Pongamia pinnata* (Patil, *et al.*, 2011), *Jatropha curcas* (Geetanjali *et al.*, 2003), *Madhuca latifolia* (George *et al.*, 2003), *Acacia nilotica* (Chillar *et al.*, 2002) and *Prosopis juliflora* (Chopra and Hooda, 2002). The present study was also corroborated these findings.

## 5.2 NURSERY EVALUATION

The seedling height of the selected candidate plus trees showed significant differences in the initial growth performance (Table 3). This same trend was reported by Lester (1970) in. The CPT- 6 from the central midland of the Thrissur had the maximum height of 42cm. Similar and high performance was obtained from midland of Palakkad for *Ailanthus triphysa* (Paul, 2017). Such a trend has also been documented among seed sources for vigour indices in many tropical species like *A. Nilotica* (Chillar, 2002) and *Prosopis juliflora* (Chopra, 2002). Paul (2017) obtained a lowest value from the Midland region, this variation may due to the genetic characters of the seeds or by the environmental factors. Salazar (1989) documented considerable differences between the 16 seed sources of *Acacia mangium* when grown in nursery and more than 93% of the variation in plant growth was attributed to provenances. While Salazar (1986) reported low genetic variation between 10 provenances from Guatemala and Costa Rica for seedling traits of *Gliricidia sepium.* Dhillon and Khajuria (1994) reported significant inter-genotypic differences for seed and seedling traits among nine genotypes of *Acacia nilotica.* The shoot length was significantly influenced by seed source (Chhaganbhai, 2014). The differences among 20 genotypes of plus tree progenies were noticed for morphological and biomass traits (Wani and Ahamed, 2013). Significant differences were noticed among populations for the germination and seedling growth characteristics of *B. variegata,* (Dhaka *et al.*, 2016). Chauhan *et al.* (2010) also reported a significant variation in seedling growth parameter among progenies of *Pongamia pinnata.*

The collar diameter of the seedlings of the selected progenies showed significant differences (Table 4). The superiority in collar diameter was exhibited by CPT-11 which also exhibited superior collar diameter at field environment. The inferior collar diameter was observed from CPT-12, same significant difference in collar diameter was found out by (Chhaganbhai, 2014). Within zones

sub - humid to humid eastern and south eastern uplands and semi-arid lava plateaus and central highlands had significantly different impact on collar diameter (Ghosh and Sing, 2011). Paul (2017) also found a significant difference in collar diameter in *Ailanthus triphysa* selected from different seed sources while a non-significant result was observed by (Chauhan *et al.*, 2010). Similar variations were observed by the Salazar (1989) in *Acacia mangium* also.

With respect to both the number of leaflets and number of leaves, the CPT-11 performed best and CPT-1 was the inferior one. The number of leaves per plant were significantly influenced by seed source (Santoso, 2011and Chhaganbhai, 2014) in *Simarouba glauca.* The variation between the treatments may be due to genetic characters of the collected seeds. However, a non-significant result was reported in this parameters by Paul (2017) from different seed sources of the selection of the *Ailanthus triphysa*.

In current study got significant differences in root parameters like taproot length, number of secondary and tertiary roots up to the six month of transplanting (Table 5, Table 8, and Table 9). The root parameters are said to be the best parameters for assessing the quality of the seedlings. Paul (2017) observed that selection from the coastal sandy (CPT-11) is superior for all root parameters followed by the CPT-10. In the case of root length the inferior one was CPT5 varies from 11.66 cm to 22.56 cm. And for secondary and tertiary roots CPT-1 was the inferior progeny. This may due to the genetic constituent of the collected seeds. This trend in variation was also reported by Ghildiyal *et al.* (2009) in *Pinus roxburghii*, Kumar *et al.* (2007) in *Pongamia pinnatta*.

Significant difference was observed for the biomass attributes, the fresh weight of the stem gives the maximum value of 24.57g after 180DAP (Table 10). As expected, the same trend has existed in fresh weight per plant also. Biomass was significantly influenced by seed source (Chhaganbhai, 2014). Paul (2016) observed a non-significant difference after150 DAP for *Ailanthus triphysa*. The

maximum dry weight of the stem was observed by CPT-11 with value of 14.64 g (Table.8). The dry weight per plant was significantly influenced by seed source (Chhaganbhai, 2014) while a non-significant difference was reported by Paul (2016) in *Ailanthus triphysa*. Fresh and dry weight of the roots also showed a significant difference from the selections of the *Ailanthus triphysa* (Table 4.11 and Table 4.12). Significant variations reported for all morphological and biomass traits (Chhaganbhai, 2014). Similar variations was found by Kumar *et al.* (2008) in *Pongamia pinnata*, Shu *et al.* (2012) in *Mangnolia officinalis* and Liu (2002) in *Camptotheca acuminata*. Chauhan *et al.* (2010) found a non-significant result in the biomass of shoot, leaf and root among progenies of 20 CPTs of *Pongamia pinnata*.

Present work revealed variation in germination and seedling growth characters of the progenies grown from the seeds collected from different selections of candidate plus trees of *Ailanthus triphysa*. Variation in germination and seedling growth traits of the progenies of trees growing at different localities with different environmental conditions have also been reported by various workers earlier in different species, *e.g.* Jaswal (1992) in *Grewia optiva*, Goel *et al.* (1997) in *Prosopis juliflora*, Manga and Sen (1998) in *Prosopis cineraria,* Ginwal *et al.* (1995) in *Acacia nilotica,* Thakur and Thakur (2015) in *Melia azedarach,* Gunaga *et al.* (2010) in *Tectona grandis* and Srivastava (1995), Anand (2003), Thakur *et al.* (2009), Wani and Wani (2014) in *Bauhinia variegata*. Variation in germination and seedling growth traits can also be attributed to the genetic makeup of parent trees and thereby their progenies as these trees are of seedling origin and are expected to show heterozygosity.

## 5.3 FIELD EVALUATION

The performance of the progenies of the selected candidate plus trees showed a significant variations in the growth attributes. From the field trial, the

CPT-11 was the superior in the plant height, while the CPT-1 was the inferior among the selected progenies (Table 16) which showed a significant difference in the plant height. Similar results was obtained by Paul (2017) in 180 DAP of *Ailanthus triphysa*. Uniyal *et al.* (2003) found a significant Increase in the plant height of G. *Oppositi folia* from the different seed sources. Such findings was also reported in *Acacia catechu* (Ramachandra, 1996), *Terminalia* spp. (Chauhan, 1998), *Dalbergia sissoo* (Singh and PokhriyaI, 2000), *Betula* spp (Holm, 1994), *Pinus brutia* (lsik, 1996) and poplar hybrid (Pliura *et al.* (2007). The better height increment was obtained by selection of the 37 accessions of *Ceiba pentandra* with significant difference (Abengmeneng *et al.*, 2015). This may be due to the seeds collected from different locations and genetic characters of mother plant or impact of mother plant and the field environment.

In relation to the plant height, the collar diameter also showed similar trend (Table 17). The same tree, CPT-11 was also superior in collar diameter. The progeny attained a maximum of 20mm collar diameter. Paul (2016) also reported a significant difference in collar diameter of *Ailanthus triphysa*, while Indira (1996), reported a significant difference in the plant height within the selections and there is no significant difference in collar diameter, similar result was also reported by Brodie and Debell (2004) in poplar.

The number of branches and leaves also showed a significant difference between the candidate plus trees. The maximum number of branches and leaves were observed from CPT-11 and the inferior one was the CPT-1. Significant difference in seedling growth attribute was observed in *Azadirachta indica* (Syed *et al.*, 2013) *Populus deltoids* (Jha, 2012), *Pongamia pinnata* (Divakara and Rameshwar Das, 2011), *Gmelina arborea* (Kumar, 2007) *Jatropha curcas* (Ginwal *et al.*, 2004), *Populus deltoides* (Singh *et al.*, 2001) and *Santalum album* (Krishna Kumar *et al*, 2017).Ginwal *et al.* (2004), Ginwal *et al.* (2005) and Kaushik *et al.* (2007) reported significant variations in seed morphology and seedling growth variables like seedling height, collar diameter, leaves, and seed weight in *J. curcus*. The survival percentage after the 180 DAP was 98.14 per

cent.This result may due to the environmental and genetic influence of the selected seeds. The difference in observation on number of forking of the progenies was not prominent. This may due to the six month period which may not be sufficient for a noticeable change or may be due to the lack possibility of forking due to the phenotypic selection made on the mother tree.

# SUMMARY

# SUMMARY

The selection and evaluation of superior quality planting material of *Ailanthus triphysa* was carried out in the tree nursery of College of Forestry, Vellanikkara, Thrissur, Kerala during 2016-2017 and the field trial was conducted at Instructional Farm, KAU with the main objective to evaluate the initial growth performance of the progenies from the selected candidate plus trees.

After a preliminary survey conducted through the agro ecological regions of Thrissur district, twelve candidate plus trees of *Ailanthus triphysa* were identified and selected by comparison tree method. From the selected candidate plus trees, seeds were collected for the study, propagated in the tree nursery and evaluated the germination parameters like germination percentage, mean daily germination, peak value of germination, germination value. The nursery performance was assessed by measuring the seedling height, collar diameter, number of leaves, number of leaflets, taproot length, number of secondary roots, number of primary roots, fresh and dry weight of shoot and root, shoot length, root length and biomass ratio at monthly interval for period of six months. The nursery evaluation was done in completely randomised design (CRD) and data analysed. For evaluating the initial growth performance of the CPTs in the field environment, the propagated progenies were out planted in a randomised block design (RBD). The parameters observed were plant height, collar diameter, number of leaves, number of branches, number of forking and field survival percentage for a period of six months.

The salient findings of the study are summarised as follows.

1. The selected candidate plus trees showed significant difference in the germination parameters studied.
2. The selections of CPT-11, CPT10, and CPT-9 showed the highest germination percentage and other parameters like mean daily germination; germination value and peak value of germination and the CPT-1 exhibited the lowest performances in almost all the germination parameters studied.

3. The nursery performance of the selections also showed significant differences in seedling height, collar diameter, number of leaves, number of leaflets, taproot length, number of secondary roots, number of tertiary roots, fresh and dry weight of shoot and root and root - shoot length ratio
4. The variation in root - shoot biomass ratio of selected CPTs were significant from 30 DAP to 60 DAP, FROM 90 DAP to 150 DAP the result was not significant.
5. The selections of CPT-11, CPT10, and CPT-9 shown superiority for most of the characters examined and the CPT-1 was the inferior in the nursery evaluation also.
6. Initial growth performance in the field also showed significant difference in plant height, collar diameter, number of leaves and number of leaflets.
7. The selections with superior growth performance in the nursery continued their superior performance (CPT-11, CPT10, and CPT-9) in the field also.
8. The CPT-5 performed better at the field even with a lower performance at the nursery.
9. The improvement of the tree can be achieved through systematic and careful selection of the mother plant and its propagation.

In conclusion, from the present investigation, it is clear that there existed wide variation among the selected CPTs of *Ailanthus triphysa* with respect to their initial growth performance. The CPT-11, CPT-10 and CPT-9 emerged to be the best on the basis of both the nursery and field evaluation. It implies strongly that these CPTs could be recommended and used for tapping the immediate gain by large scale planting and afforestation programmes and also for further breeding programmes for the genetic improvement of the widely accepted and cultivated tree species of *Ailanthus triphysa.*

# REFERENCES

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Abengmeneng, C.S., Ofori, D.A., Kumapley, P., Akromah, A., and Jamnadass, R. 2015.Estimation of heritability and genetic gain in height growth in *Ceiba pentandra. Academic. J.* 14(22):1880-1885.

Aldhous, J.R. 1972. *Nursery Practice.* Forestry Commonwealth Bulletin No. 45, London, 17p.

Anand, R.K. 2003. Nursery evaluation of plus tree progenies of *Bauhinia variegate* Linn. M.Sc. thesis, Dr YS Parmar University of Horticulture & Forestry, Solan (HP), 102p.

Anand, R.K., and Dwivedi, S.V. 2014. Association studies for morphological and biomass traits of *Bauhinia variegate* Linn. *Int. J. Agric. Sci.* 10(1): 61-65.

Andersson, L. and Milberg, P. 1998. Variation in seed dormancy among mother plants, populations and years of seed collection. *Seed Sci. Res.* 8:29-38.

Arya, S., Toky, O. P., Bisht, R. P., Tomar, R. and Harris, P. J. C. 1995. Provenance variation in seed germination and seedling growth of *Prosopis cineraria* (L.) Druce in arid India. *Silvae Genetica*. 55p.

Aslam, M., Reshi, Z.A., and Siddiqi, T.O. 2010. Variability in cone and seed characteristics among plus trees of blue pine (*pinus wallichiana*A. B. Jackson) in the Kashmir Himalaya, India. *Int. J. Pharma. Biosci.* 1(4):212-223.

Aslam, M.O.H.D., Reshi, Z.A. and Siddiqi, T.O., 2011. Genetic divergence in half-sib progenies of *pinus wallichiana* A. B. Jackson plus trees in the Kashmir Himalaya, India. *Trop. Ecol. 52*(2):201-208.

Bahar, N., 2008, Studies on seed source variation in *Albezia lebbeck* (L.) Benth. *Indian J. For.* 31(3):417-422.

Basak, R.K. 1980. Simaroubaceae. In: *Fasc. Fl. Ind.* Botanical Survey of India, 4: 1-24.

Becker, W.A., 1967.*Manual of procedures in quantitative genetics.*(2nd Ed.). Student Book Corporation, Washington State University, Pullman, U.S.A, 130p.

Bewley, J.D. and Black, M. 1994. *Seeds: physiology of development and germination.* Plenum Press, New York, 211pp.

Bhat, G. S. and Chauhan, P. S. 2002. Provenance variation in seed and seedling traits of *Albizzia lebbek* Benth. *J. Tree Sci.* 21 (2): 52 - 57.

Bhatt, I. D., Rawat, R. S., and Dhar, U. 2000. Improvement in seed germination of *Myrica esculenta* Buch. Ham ex. D. Don-a high value tree species of Kumaun Himalaya, India. *Seed Sci. Technol.* 28:597-605.

Bhattacharya, A. and Mandal, S. 2000. Pollination biology in *Bombax ceiba* Linn. *Curr. Sci. Bangalore. 79*(12):1706-1711.

Brodie, L.C. and Debell, D.S. 2004. Evaluation of field performance of poplar clones using selected competition indices. *New For. 27*(3):201-214.

Chauhan, S. 1998. Germination behaviour of three *Terminalia* spp. [unpublished D.Phil. thesis. Srinagar Garhwal, India: H.N.B. Garhwal University, 141pp.

Chauhan, R., Chakma, T., and Rao, P.V. 2010. Evaluation of progenies of candidate plus trees of *Pongamia pinnata*(L.) Pierre. For seed germination and seedling vigour. *Curr. Sci.* 100(4):465-467.

Chhaganbhai, B. H. 2014. Influence of seed source variation and potting mixtures on germination of *Ailanthus excelsa.* Msc (for) thesis, Navsari agricultural university, Navsari. 80p.

Chillar, S., Hooda, M.S., and Chopra, D. 2002. Seed source variation in *Acacia nilotica* (L.) wild. *Indian J. For.* 25(2): 150-153.

Chopra, D. and Hooda, M.S. 2002. Variability in mineral content of *Prosopis juliflora* seeds collected from different places. *Indian J. Anim. Nutr.* 19(2):162-165.

Cornelius, J. 1994. The effectiveness of plus-tree selection for yield. *For. Ecol. Manage.* 67(1-3):23-34.

Costales, A. B. and Veracion, V. P. 1978. Germination of Benguet pine seeds at various intervals of watering. *Sylva. Trop.* 3(4):243-245.

Dabgar, V. M., Manjunatha, G. O., Kumar, P. H., and Patil, S. K. 2007. Seed source variation for seed traits in *Jatropha curcas*. ISOR, National Seminar, 374-376.

Dhaka, R.K., Jha, S.K., Dhaval, B. C., and Prajapati, D.R. 2016. Variability, heritability, genetic advance, genetic gain and correlation in relation to germination and seedling growth characteristics of different populations of

*Bauhinia variegate* Linn. In the Dangs Forest of Gujarat. *Adv. Life. Sci.* 5(21):9944-9948.

Dhillon, G. P. S. and Khajuria, H. N. 1994. Genotypic variation in germination and potential in *Acacia nilotica*(L.) seeds. *Indian J. For.* 17:345-347.

Dhillon, R. S. 2003. Genetic variation, heritability and correlations for growth parameters in *Azadirachta indica* A. Juss. *An. For.* 11: 215-221.

Divakara, B. N. and Das, R. 2011. Variability and divergence in *Pongamia pinnata* for further use in tree improvement. *J. For. Res.* 22(2):193-200.

Dlamini, C.S. 2010. Provenance and family variation in germination and early seedling growth in *Sclerocarya birrea* sub-species *caffra*. *J. Hortic. For.* 2(9): 229-235.

Dorman, K.W. 1976. The genetics and breeding of southern pines. USDA For Serv Agric Handbook No. 471. p 407.

Dwivedi, A. P. 1993. National level of Neem Seed source trials at Jodhpur. *Syst. Ecol.* 5(7):20-34.

Falconer, D.S. 1960. Introduction to quantitative genetics. Ronald Press, New York 365 pp.

Fenner, M. 1991. The effects of the parent environment on seed germinability. *Seed Sci. Res.* 1:75-84.

Floistad, I.S., Nyeggen, H., and Skage, J.O. 2017. Field trials with *Abies lasiocarpa* progenies from plus trees and seed orchard clones for Christmas tree production in Norway. [On line] 32(5). Available.

https://doi.org/10.1080/02827581.2017.1297481. ISSN: 0282-7581 [17Feb 2017].

Geethanjali, K. Balasubramanian, A. and Paramathma, M. 2003. Seed technological studies in *Jatropha Curcus. Nation. Workshop Jatropha Other Perennial Oil Seed Species*, 5th to 8th Aug.2003, Bharathiya Agro-Industries Federation of India (BAIF), Pune: 31-33.

George, J. M., Dasthgiri, P.K., and Judesudhagar. 2003. Variability studies in seed and seedling attributes in Mahauva (*Madhuca latifolia*). *Indian For.*129 (4):509-516.

Gera, N., Gera, M., Purohit, M. and Agarwal, R., 2001, Intra-Population variation in *Albizia procera:* pod, seed and germination characteristics. *Indian For.* 127(9): 963-972.

Ghildiyal, S.K., Sharma, C.M., and Gairola, S. 2009. Additive genetic variation in seedling growth and biomass of fourteen *Pinus roxburghii* provenances from Garhwal Himalaya. *Indian. J. Sci.Technol.* 2(1):37-45.

Ghosh, L. and Singh, L. 2011. Variation in seed and seedling characters of *Jatropha curcas* L. with varying zones and provenances. *Trop. Ecol.* 52(1):113-122.

Ginwal, H.S. and Gera, M. 2000. Genetic variability in seed, germination and growth performance of 12 *Acacia nilotica* provenances in India. *J. Trop. For Sci.* 12(2):286- 297.

Ginwal, H. S., Phartyal, S.S., Rawat, P.S., and Srivastava, R. L. 2005. Seed source variation in morphology, germination, and seedling growth of *Jatropha curcas* Linn. In Central Asia. *Silvae Genetica* 54:76-80.

Ginwal, H.S., Rawat, P.S., Gera, N. and Srivastava, R.L. 1995. Study on the pattern of seed germination of various sub-species cum provenances of *Acacia nilotica* under nursery conditions. *Indian For.* 121(1):22-37.

Ginwal, H. S., Rawat, P. S., and Srivastava, R. L. 2004. Seed source variation in growth performance and oil yield of *Jatropha curcas*Linn. In Central India. *Silvae Genetica.*53:186-192.

Glendinning, A., Mahapatra, A., and Mitchell, C.P. 2001. Modes of Communication and Effectiveness of Agroforestry Extension in Eastern India. *Hum. Ecol.* 29(3): 283-284.

Goel, V.L. and Behl, H.M. 2001. Genetic selection and improvement of hard wood tree species for fuelwood production on sodic soil with particular reference to *Prosopis juliflora. Biomass. Bioenergy*, 20(1):9-15.

Goel, V.L., Dogra, P.D. and Behl, H.M. 1997. Plus tree selection and their progeny evaluation in *Prosopi sjuliflora. Indian. For*, 123(1-6): 196-205.

Gunaga, R.P., Prabhu, H.N. and Surendra, T. 2010. Variation in seedling characteristics among five seed sources of teak (*Tectona grandis*LF) in Kerala. *The Indian Forester*, 136(11):1478-1485.

Hamrick, J.L. and Godt, M.W. 1990. Allozyme diversity in plant species. *Plant population genetics, breeding, and genetic resources.* pp43-63.

Hembrom, I., Gargi., Kumar, R., Singh, M. K., and Vijayprakash, N. B. 2010. Provenance variations in seed characteristics and germination behaviour of *Terminalia arjuna*and *Terminalia tomentosa. Indian For.*136(5): 217-219.

Holm, S.O. 1994. Reproductive patterns of *Betula pendula* and B. *pubescens* along a regional altitudinal gradient in northern Sweden. *Ecography* 17:60-72.

Indira, E.P. 1996. Genetic improvement of *ailanthus triphysa.* Thrissur: Kerala forest research institute.26p.

Isik, K. and Kara, N. 1996. Altitudinal Variation in *Pinus brutia* Ten. And it's Implication in Genetic Conservation and Seed Transfers in Southern Turkey. *Silvae Genetica.* 46(3):113-120.

Isik, K.1986. Altitudinal variation in *Pinus brutia* Ten: seed and seedling characteristics. *Silvae Genetica.* 35:58-67.

Jaswal, S.C. 1992. Seed Source Studies in *Grewia optiva* Drummond - an Agroforestry Tree Species. Ph.D. Thesis submitted to Dr YS Parmar University of Horticulture & Forestry, Solan (HP).

Jayasankar, S., Babu, L. C., Sudhakara, K. and Dhanesh Kumar, P. 1999. Evaluation of Provenances for Seedling Attributes in Teak (*Tectona grandis LINN. F.). Silvae Genetica.* 48(3–4):115-122.

Jha, R. K. 2012. Study of variability, associations and path analysis in poplar (*Populus deltoids* Bartr. Ex Marsh). *J. Sustain. For.*31: 185-204.

Jose, D. 1992. Structure and productivity of the homegardens of Kerala: a case study. In: Nair C.G.R (ed.). Proc. Fourth Kerala Science Congress, February 1992. Thrissur. pp. 17-19.

Kang, K.S., Cappa, E.P., and Hwang, J. 2010. Growth Characteristics of 100 Open-pollinated Families in an Early-age Test of *Agathis loranthifolia* in West Java, Indonesia. *J. Korean. For. Soc.* 99(2):213-219.

Kaproth, M.A. and McGraw, J.B., 2008. Seed viability and dispersal of the wind-dispersed invasive *Ailanthus altissima* in aqueous environments. *For. Sci. 54*(5):490-496.

Kaushik, N., Kumar, K., Kumar, S., and Roy, N. 2007. Genetic variability and divergence studies in seed traits and oil content of Jatropha (*Jatropha curcas*L.) accession. *Biomass Bioener* 31: 497-502.

Kerala Agricultural University. 2002. Package of Practices Recommendations: Crops. 12th Edition (eds. A. I. Jose et al.). Kerala Agricultural University, Trichur. 278p.

Khalil, M. A. K. 1978. Early growth of some progenies from phenotypically superior spruce provenances in central Newfoundland. II. Heritability and genetic gain. *Silvae Genetica* 27(5):192-196.

Khalil, M. A. K.1981. Correlation of juvenile height growth with cone morphology and seed weight in white spruce. *SilvaeGenetica*30:179-181.

Kowarik, I. and Säumel, I. 2007. Biological flora of central Europe: *Ailanthus altissima* (Mill.) swingle. *Perspectives. Plant .Ecol. Evol. Syst. 8*(4):207-237.

Krishnakumar, N., Parthiban, K.T., Jayamani, P., Revathi, R., and Umeshkanna, S. 2017. Genetic variability of growth parameters among different progenies of *Santalum album* l. *J. Indian Soc. Coastal Agric. Res.* 35(1): 56-63.

Kumar A. 2007. Growth performance and variability in different clones of *Gmelina arborea* (Roxb.). *Silvae Genetica*. 56(1): 32–36.

Kumar, B. M. 2000. *Ailanthus triphysa* in the homegardens of Kerala:occurrence, basal area, average standing stock of wood and diameter structure.*IndianJ.Agrofor.*2:49-52.

Kumar, R., Nautiyal, S., and Bahuguna, A. 2004. Seed source variation in Khair (*Acatia catechu*Willd.). *Indian. For.* 130(5):530-536.

Kumar, S., 2003, Effect of seed size on germination and seedling traits of *Jatropha curcas.* National workshop on Jatropha and other perennial oil seed species, August 2003, BAIF, Pune, pp. 5-7.

Kumar, S., Radhamani, J., Singh, A.K., and Varaprasad, K.S. 2007. Germination and seed storage behaviour in *Pongamia pinnata* L. *Curr. Sci.* 93: 910–911.

Kumar, S. and Singh, S. 2014. Variability assessment of seed traits in *Jatropha curcas*L. for improvement of oil yield. *Int. J. Genet. Mol. Biol.* 6(1):8-15.

Kumari, G. and Wani, A.F. 2015.Seed source variability in half sib families of *Diospyros melanoxylon* roxb. Under open field condition. *Int. J. Adv. Res.* 3(11):161- 168.

Lal P., Kulkarni H.D., Srinivas K., Venkatesh K.R. and Santakumar P. 1997. Genetically improved clonal planting stock of Eucalyptus – a success story from India. *Indian For.* 123: 1117–1138.

Lande, R. and Shannon, S., 1996. The role of genetic variation in adaptation and population persistence in a changing environment. *Evolution*. *50*(1):434-437.

Lazdiņa, D., Šēnhofa, S., Zeps, M., Makovskis, K., Bebre, I. and Jansons, Ā. 2016. The early growth and fall frost damage of poplar clones in Latvia. *Agron. Res. 14*(1):109-122.

Lester, D.T. 1970. Variation in seedling development of balsam fir associated with seed origin. *Can. J. Bot. 48*(6):1093-1097.

Li, B., McKeand, S. and Weir, R., 1999. Tree improvement and sustainable forestry–impact of two cycles of loblolly pine breeding in the USA. *For. Genet*, *6*(4):229-234.

Liu, Z., Zhou, G., Xu, S., Wu, J. and Yin, Y. 2002. Provenance variation in camptothecin concentrations of *Camptotheca acuminata* grown in China. *New for. 24*(3):215-224.

Longman, K.A. and Jenik, J. 1987. *Tropical Forest and its Environment*. (2nd edn). Longman Scientific and Technical, Harlow, UK, VI+ 347 pp.

Mahto, L. B., Oraon, P. R., and Siddiqui, M. H. 2006. Seed characteristics and germination of three provenances of *Azadirachta indica*. *My For.* 42(4):419-423.

Majumder, D. A.N., Hassan, L., Rahim, M.A., and Kabir, M. A. 2012. Correlation and path coefficient analysis of mango (*mangifera indica* .). *Bangladesh J. Agric. Res*. 37(3): 493-503.

Manga, V.K. and Sen David, N. 1998. Variability and association among root and shoot traits in seedlings of *Prosopis cineraria*. *J. Tree Sci.,* 17(1&2): 33-38.

McKeand, S.E. 1988. Optimum age for family selection for growth in genetic tests of loblolly pine. *For. Sci.* 34(2):400-411.

Meena, D., Singh, A., and Sharma, A. 2016. Studies on seeds germination and seedling growth of *Tecomella undulate* at nursery stage. *Int. J. Agric. Environ. Res.* 2(3):314-321.

Meena, H., Kumar, A., Sharma, R., Chauhan, S.K. and Bhargava, K.M. 2014. Genetic variation for growth and yield parameters in half-sib progenies of *Melia azedarach* (Linn.). *Turkish J. Agric. For. 38*(4):531-539.

Mohamed, M.B.N., Parthiban, K.T., and Ravi, R. 2015a. Genetic association studies among growth attributes in provenances of *Aquilaria malaccensis* Lam. *J. Int. Acad. Res. Multidisciplinary.* 3(1):191-200.

Mohamed, M.B.N., Parthiban, K.T., Ravi, R. and Kumar, P. 2015b. Provenance variation in growth and genetic potential of *Aquilaria malaccensis* under nursery condition. *Afr. J. Biotech. 14*(24):2005-2013.

Morgenstern, E.K., Holst, M.J., Teich, A.H. and Yeatman, C.W. 1975. *Plus-tree selection: review and outlook* (Vol. 1347). Department of the Environment, Canadian Forestry Service.

Moya, R., Fallas, R.S., Bonilla, P.J., and Tenorio, C. 2012. Relationship between wood color parameters measured by the CIELab system and extractive and phenol content in *Acacia mangium* and *Vochysia guatemalensis* from fast-growth plantations. *Molecules. 3640-3652.*

Nair, M.A. and Sreedharan, C. 1986. Agroforestry farming systems in the homesteads of Kerala, southern India. *Agrofor. Sys. 4*(4):339-363.

Nayak, B. G., Shapumath, G., Gunaga, R. P., Shivanna, H. and Lingaraj, S. S. 2004. Seed source variation in seed and seedling attributes of *Albizia lebbeck*. *My For.,* 40 (1): 77-83.

Nienstaedt, H. 1981. *"Super" Spruce Seedlings Continue Superior Growth for 18 years.* U.S. Department of Agriculture Forest Service Research Note NC - 265. 4 pp.

Okoro, O. O. 1976. Germination of *Terminalia ivorensis*seeds sown under various conditions of germination. In "Seed Problems". Paper presented at Second International Symposium on Physiology of Seed Germination. October 1976, IUFRO, Fuji, Japan.

Oyebade, B. A., Ekeke, B. A., and Aigbe H. I. 2012. Provenance variations in *Chrysophyllum albidum (G. Don)* from six localities in rivers state, Nigeria. ARPN. *J. Agric. and Biol. Sci.,* 7(3): 157-162.

Palanisamy, M., Gireesan, K.,Nagarajan, V., andHegde, M. 2008. Selection and clonal multiplication of superior trees of teak *(tectona grandis)* and preliminary evaluation of clones. *J. Trop. For. Sci.* 21(2): 168–174.

Paray, P.A., Gangoo, S.A., Bhat, S.J.A., Bhat, A., and Parray, A.A. 2017.Estimates of Genetic Parameters and Correlation in Catkin and Seed Traits of *Salix alba. Int. J. Curr. Microbiol. App. Sci.* 6(5):1601-1608.

Patil, V. M. H., Shivanna, P., Surendra, G. O., Manjunath, A., Krishna and Dasar, G. V. 2011.Variability studies for seed and seedling traits in *Pongamia pinnata*(L.)Pierre. *Karnataka J. Agric. Sci.* 24 (2):201-203.

Paul, B.N. 2017. Screening of *Ailanthus triphysa* (Densst,) Alson. For preferred matchwood qualities. Msc (For) thesis, Kerala Agricultural University, Thrissur. 93p.

Pliura, A., Zhang, S.Y., MacKay, J. and Bousquet, J. 2007. Genotypic variation in wood density and growth traits of poplar hybrids at four clonal trials. *For. Ecol. Manage. 238*(1):92-106.

Raebild, A.,Diallo, B.O., Graudal, l., Dao, M., and Sanou, J. 2003. Evaluation of a species and provenance trial of Acacia nilotica and A. Tortilis at Gonsé, Burkina Faso. Trial no. 11 in the arid zone series Results and Documentation No. 10. Danida Forest Seed Centre, Humlebaek, Denmark.1-34.

Ramachandra NG. 1996. Provenance variation in seed and seedling parameters in *Acacin catechu* Willd. PhD (For) thesis. Dehradun, India: Deemed University, Forest Research Institute (FRI).

Ramesh, K.R. and Khurana, D.K. 2003. Natural provenance variation on *Populus alba* Linn. From western Himalaya. *Indian. For.* 129(9):1077-1084.

Rao, G.R., Korwar, G.R., Shanker, A.K. and Ramakrishna, Y.S. 2008. Genetic associations, variability and diversity in seed characters, growth, reproductive phenology and yield in *Jatropha curcas* (L.) accessions. *Trees*, *22*(5):697-709.

Rawat, K., and Bakshi, M. 2011, Provenance variation in cone, seed and seedling characteristics in natural populations of *Pinus wallichiana* A. B. Jacks (Blue Pine) in India. *Ann. For. Res.,* 54(1): 39-55.

Rawat, K., Tyagi, M., Nautiyal, S and Kumar, P. 2006, variability studies of different seed sources of *Pinus wallichiana* with special reference to seed and germination characteristics. *Indian For.*373-379.

Reddy, K. N. V., Kumar, P. H., Siddraju, C. M., Gunga, R. P., Madiwalar, S. L., and Patil, S. K. 2007. Seed source variation for seed and seedling traits in *Pongamia pinnata*(L.) Pierre; An important biofuel yielding tree species. *My For.* 43(1): 61-68.

Sahoo, D.P., Rout, G.R., Das, S., Aparajita, S., and Mahapatra, A.K. 2011. Genotypic Variability and Correlation Studies in Pod and Seed Characteristics of *Pongamia pinnata* (L.) Pierre in Orissa, India. *Int. J. For, Res.* 1-6.

Salazar R. 1986. Genetic variation in seeds and seedlings of ten provenances of *Gliricidia sepium* Oacq.) Steud. *For. Ecol. Manage.* 28(2):141-151.

Salazar, R. 1989. Genetic variation of 16 provenances of *Acacia mangium* at nursery level in Turrialba, Costa Rica. *Commw. For. Rev.*263-272.

Sankhyan, H.P., Singh, N.B., and Kairon, V. 2015. Studies on the variability analysis in soapnut (*sapindus mukorossi.*) of Himachal Pradesh. *Int. J. Agric. Sci. Vet. Med.*3 (2):32-37.

Santoso, B.B. 2011. Variation in oil contents, and seed and seedling characteristics of *Jatropha curcas*of West Nusa Tenggara selected genotypes and their first improved population. *Nubiosci.* 3(3): 130-135.

Sasikumar, K. 2003. Clonal evaluation of *Eucalyptus tereticornis* Sm. and Acacia hybrids and interspecific hybridization between *A. auriculiformis, A. Cunn.*

*ex. Benth. and A. mangium* willd. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore.

Sharma, A. and Bakshi, M. 2014. Variability in Growth, Physiological, and Biochemical Characteristics among Various Clones of *Dalbergia sissoo* in a Clonal Seed Orchard. *Int. J. For. Res.*1: 1-9.

Shinde, P.P., Rane, A.D., Gunaga, R.P., and Narkhede, S.S. 2012. Variability and Genotype Selection in *Callophyllum inophyllum* for Quality Fruit Yield in the Central West Coast of India. *J. Tree. Sci.* 31(1):8-14.

Shivanna, H., Balachandra, H. C., and Suresh, N. L.2007. Source Variation in Seed and Seedling Traits of *Pongamia pinnata*. *Karnataka J. Agric. Sci.*20 (2):438–439.

Singh N, Pokhriyal, T.C. 2000. Biomass distribution pattern in relation to seed source variation in *Dalbergia sissoo* seedlings. *Ann. For.* 8(2):238-249.

Singh, N.B., Kumar, D., Rawat, G.S., Gupta, R.K., Singh, K. and Negi, S. S. 2001. Clonal evaluation of Poplar (*Populus deltoids* Bartr.) in eastern Uttar Pradesh II – Estimates of genetic parameters in field testing. *Indian For.* 127(2): 163-172.

Singh, O. and Sofi, A.H. 2011. Clone variation of seed traits, germination and seedling growth in *Dalbergia sissoo* Roxb. Clonal seed orchard. *Ann. For. Res. 54*(2):139-142.

Sivakumar, V., Parthiban, K. T., Singh, B. G., Gnanambal, V. S., Anandalakshmi, R. and Geetha, S. 2002. Variability in drupe characters and their relationship on seed germination in teak (*Tectona grandis* L. f.). *Silvae Genetica.* 51(5–6): 232-237.

Srivastava, A. 1995. Seed Source Variation Studies in *Bauhinia variegate* Linn. M.Sc (Ag) Thesis submitted to Dr YS Parmar *University* of Horticulture & Forestry, Solan (HP), 96p.

Syed, M., Gupta, V.K. and Pandey, H. C. 2013. Studies of phenotypic and genetic variation in various growth characters in neem (*Azadirachta indica* A. Juss) germplasm. *Agric. Sci. Res. J.* 3(3): 72-78

Takuathung, C. N., Pipatwattanakul, D., and Bhumibhamon, S. 2012. Provenance variation in seed morphometric traits and growth performance of *Senna siamea (Lam.)* Erwin ETBarneby at Lad Krating Plantation, Chachoengsao Province, Thailand. *Kasetsart J. Nat. Sci.* 46:394 – 407.

Thakur, I.K., Chauhan, K.C, and Singh, C. 2009. Evaluation and genetic improvement through progeny trials in different provenances of *Bauhinia variegate* suitable for foothills of the Himalayas. *Indian J. Soil Conserv.* 37(3): 185- 192.

Thakur, I.K. and Thakur, Shikha. 2015. Variabilty, heritability, genetic gain, genetic advance and correction in growth characteristics of progenies of *Melia Azedarach*. *Indian For.* 141(3): 247-253.

Uniyal, A.K., Bhatt, B.P., and Todaria, N.P. 2003. Effect of provenance variation on seed and seedling characteristics of *Grewia opposififolia* Roxb. a promising agroforestry tree-crop of Central Himalaya, India. *Plant. Genetic. Resour.* 136: 47-53.

Vakshasya, R.K., Rajora, O. P. and Rawat, M. S. 1992. Seed and seedling traits of *Dalbergia sissoo* Roxb. Seed source variation studies among ten sources in India. *For. Ecol. Manage.* 48: 265-275.

Vera, M.L.1997. Effects of altitude and seed size on germination and seedling survival of heathland plants in north Spain. *Plant Ecol.* 133:101-106.

Verma, R.C. and Bhagarwa, K.S. 2007. Variability, heritability and genetic advance for growth parameters in *Populus deltoides*. *Indian. For.* 133(4):506-510.

Vidyasagaran, K., Kumar, V., and Ajeesh, R. 2014. Utilization of municipal garbage as component potting media for the production of teak (*Tectona grandis* l.f.) Seedlings in the nursery. *Ecoscan*. 8(3&4): 215-219.

Wani, A.M. and Wani, M.S. 2014.Study on Heritability and Genetic Gain in Plus Tree Families of *Bauhinia variegata* L. In Western Himalayas. *Int. J. Advanced. Res.* 2(8): 938-946.

Wani, M.S. and Ahmad, L. 2013. Estimation of field environment variability for germination and seedling traits in *Madhuca indica* Gmel. *Am. J. Exp. Agric.* 3(2):361-373.

Whittington, W. J. 1973. Genetic regulation of germination. In Seed Ecology, ed. W. Heydecker. Univ. Park: Penn. St. Univ. Press. , pp. 5-30.

Willan, R. L. 1985. A Guide to Forest Seed Handling with Special Reference to the Tropics. FAO Publications, Rome.

Witcombe, J. R. and Whitiington. 1972. The effects of selection for reduced dormancy in Charlock (*Sinapis arvensis*). *Heredity*. 29:37-49.

Wright, J.A., Osorio, L.F. and Dvorak, W.S., 1995. Recent developments in a tree improvement program with *Pinus patula* in Colombia. *For. Ecol. Manage. 72*(2-3):229-234.

Zobel, B.J 1984. The changing quality of the world wood supply. *Wood Sci. Technol.*18: 1-17.

Zobel, B and Talbert, J. 1984. *Applied Forest Tree Improvement*. John Wiley & Sons Inc, New York. 505p

# SELECTION AND EVALUATION OF SUPERIOR PLANTING MATERIALS OF *Ailanthus triphysa* (Dennst.) IN THRISSUR

By

**ABIJITH R**
**(2015-17-009)**

## ABSTRACT OF THE THESIS

**Submitted in partial fulfillment of the requirement for the degree of**

## Master of Science in Forestry

**Faculty of Forestry**

**Kerala Agricultural University**


**DEPARTMENT OF SILVICULTURE AND AGROFORESTRY**
**COLLEGE OF FORESTRY**
**VELLANIKKARA, THRISSUR – 680 656**
**KERALA, INDIA**
**2018**

## ABSTRACT

A nursery and field experiment was conducted to evaluate the superior performance of selected candidate plus trees of *Ailanthus triphysa*from the Thrissur District, Kerala. The demand of this timber was very much increased because of its fast growing nature and diversity of utilizations. Hence, the tree improvement of this species is the need of the hour that might result increased quality and reduced rotation time. The possible gain expected through the phenotypic selection can also be directly utilised by the tree growers.

The candidate plus trees were identified and selected by adopting the comparison tree method. The seeds collected were used to study the germination parameters at tree nursery of College of Forestry, Kerala Agricultural University. The initial growth performances of the progenies of the selected CPTs were evaluated at nursery in a completely randomised design and also at the field in a randomised block design and the data were statistically analysed using Analysis of Variance technique.

The progenies of the selected CPTs showed significant variation in their initial growth parameters. The highest germination per cent of 83.50 was exhibited by CPT-11 and the lowest of 67 per cent by CPT-1. After the six months of observation in the nursery, CPT-11 attained the maximum height of 88.67cm and lowest height by CPT-5 (76.33cm). The maximum plant height (99 cm) and girth (21.04 cm)in the field was also exhibited by CPT-11. The CPT-11, CPT-10 and CPT-9 were the top performers compared to other selections. The CPT-1 was the inferior in the nursery and also in the field. The CPTs that exhibited superiority in germination percentage, germination value and mean daily germination also exhibited distinctively superior growth in the nursery and in the field.

In fact, the identification and selection of superior quality planting materials of *Ailanthus triphysa*has a greater role in the tree improvement. The single tree selection is the best method for the production of superior progenies and this can be useful for the future afforestation and seedling production for getting high quality timber with short rotation period. From this study we recommend CPT-11, CPT-10 and CPT-9 for achieving these objectives.