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Research Article

Diversity assessment and selection of candidate plus trees of *Ailanthus triphysa* (Dennst.) Alston in Kerala

Jes Lalnunpuia*, A. V. Santhoshkumar, T. K. Hrideek, E. V. Anoop and P. Manju Elizabeth

Department of Forest Biology and Tree Improvement, College of Forestry, Kerala Agricultural University Vellanikkara-680656, Thrissur, Kerala, India
*E-Mail: jeste14khenglawt@gmail.com

Abstract
Ailanthus triphysa [Dennst.] Alston is one of the most important and extensively used trees for making match splints in India. Despite its multiple uses, the genetic variability of the trees is little explored. The study attempted to determine the genetic diversity and select candidate plus trees from various parts of Kerala. Thirty candidate plus trees were selected based on baseline regression of trunk volume to crown volume combined with scoring for qualitative characters. The tree height, GBH, crown diameter and clean bole height of the plus trees ranged from 20 to 37 m, 0.69 to 2.11 m, 3.5 and 9.75 m and 7 to 24 m, respectively. The selected CPTs can be used for tree improvement and development of superior quality planting material.

Key words
Ailanthus triphysa, variability, CPTs.

INTRODUCTION

In India, *Ailanthus triphysa* is distributed in the evergreen forests up to 1500 m of Western Ghats, from Konkan southwards to Kerala. It is also found in Myanmar (Troup, 1921). This multipurpose tree is widely planted in all areas except high hills in Kerala (Kumar, 2000). It is a large, fast-growing evergreen tree growing up to 40 m in height. Different plant parts are used as medicine for a variety of diseases. The resin obtained from the tree has medicinal properties and widely used in the manufacturing of incense. *Ailanthus triphysa* is considered the best Indian tree species for match splints along with *Evodia lunu-ankenda* (Nair, 1961).

Even though there are multiple uses, the genetic variability of the trees is still significantly less known. Hence, this present study attempted analysis of variability in *Ailanthus triphysa* and select candidate plus trees from different parts of Kerala.

MATERIALS AND METHODS

Natural populations of *Ailanthus triphysa* were identified from selected districts of Kerala after a reconnaissance survey through stratified sampling, with low land, midland and high land as the stratas. In Thrissur district, two low land areas Anthikad and Manalur panchayaths and three midlands regions Pudukkad, Chalakudy and Wadakkannchery panchayaths were selected. In Palakkad, two high lands regions, Thrikadeeri and Ananganadi panchayaths were selected. In Malappuram, three panchayaths, two midland areas Vengara and Parappur and one high land region, Urakam panchayath was selected. The panchayaths were thoroughly searched and trees of *Ailanthus triphysa* from farmer's fields were located after the reconnaissance survey.

Plus trees of *Ailanthus triphysa* trees were selected from the natural populations of these locations. The trees were enumerated, and the location was marked using Global Positioning System (GPS). Trees above 45 cm girth at breast height were surveyed at the selected panchayaths. The tree height was measured using Laser Hypsometer and expressed in meter (m). The girth at breast height

(GBH) was measured using tape at 1.37 m. The diameter of the crown was measured as the average of the two diameters. The first axis was measured at the broadest portion of the crown, and the diameter perpendicular to this was measured as the second axis. The average of these two diameters was considered as the crown diameter. The length of the bole was measured from the ground level to the point of first branching, *i.e.*, the first living branch that forms part of the crown of the tree. The crown length was estimated as the total height of the tree minus the crown base height. Crown volume was estimated as

$$Crown\ volume = CD^2 x\ l$$

where CD represents the crown diameter of the tree and l, crown length.

$$Trunk\ volume = \left(\frac{g}{4}\right)^2 x\ l$$

Trunk volume was calculated as Quarter's girth formula,

Where g is the girth of the tree at breast height, and I is the height of the tree.

Clean bole straightness, cross-section, swellings, branching habit, branch angle, apical dominance, forking, self-pruning ability, foliar and stem damage were recorded. The variations in the qualitative traits were determined using the scoring method developed by Jayaraj (1997). A total of 255 trees were identified for assessing the variability.

Thirty plus trees were selected using the baseline regression method (Rudolf, 1956). For this, the regression

of trunk volume vs crown volume was determined. Trees above the regression lines were initially selected as plus trees and below were rejected. Among the trees falling above the regression line, those having the highest score of qualitative characteristics were selected following the scorecard developed by Jayaraj (1997).

Information on morphological characters of different plus trees was subjected to hierarchical clustering analysis. Cluster analysis was conducted using Minitab software based on squared Euclidean distance.

RESULTS AND DISCUSSION

Considerable variations in growth and qualitative characteristics were observed between trees within localities of the 255 trees enumerated in the selected panchayaths (**Table 1**). The variation in height, GBH, crown width and clean bole height ranged from 10 to 37 m, 0.48 to 2.2 m, 1.5 to 11 m and 3 to 24 m, respectively. The average height, GBH, crown width and clean bole height of the trees were 23.56 m, 0.86 m, 5.01 m and 13.61 m, respectively. The total score for all the qualitative characters ranged from 21 to 48.

Generally, the tree characters such as tree height, GBH, crown diameter etc., vary in nature. Height and GBH are commercially crucial for timber species. Growth characters like height are mostly influenced by the environment and hence have low heritability. So, selection based on height might not be the best choice. Similar observations were recorded by Abijith (2018) and Das (2018) in *Ailanthus triphysa* on the characters height, GBH and crown width. This showed that variation exists in the population is due to environmental influence and selection based on these criteria is not suggested. Similar variations were also observed in *Melia dubia* (Binu, 2019) and *Lagerstroemia speciosa* (Jamaludheen *et al.*, 1995).

Table 1. Variation in morphological characters of *Ailanthus triphysa* trees from selected panchayaths

Panchayaths	Number of trees	Height (m)			GBH (m)			Crown width (m)			Clean bole height (m)			Score		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Anthikad	24	14	26	20.5	0.5	1.1	0.7	2	8.0	4.9	4	17	10.6	27	46	33.3
Manalur	25	16	28	21.0	0.6	0.9	0.6	2.5	8.5	4.3	8	18	13.3	23	48	33.7
Pudukkad	26	16	37	26.5	0.5	1.3	0.9	3.5	8.5	6	7	24	16.7	21	48	33.8
Chalakudy	30	13	37	28.7	0.5	2.0	1.0	2.5	11	6.6	6	24	15.2	21	47	32.1
Wadakkanchery	25	15	33	25.2	0.5	1.7	1.0	2.5	9.5	5.1	4	21	14.2	22	48	32.3
Vengara	26	15	28	20.2	0.5	1.3	0.7	1.8	9.9	3.7	3	18	8.1	18	46	31.5
Parappur	22	17	27	23.1	0.5	1.1	0.8	2.2	7.5	4.2	6	19	13.0	23	48	34.1
Thrikadeeri I	25	21	34	27.1	0.6	1.9	1.2	2.5	9.5	6	13	23	18.3	20	48	32.3
Ananganadi	26	16	35	25.3	0.5	1.1	0.8	2.5	7.5	4.5	7	24	16.4	20	48	33.0
Urakam	26	10	23	17.9	0.5	2.2	0.9	1.5	10.5	4.7	3	18	10.2	24	45	31.4

The scores for the qualitative characters in this study such as verticality, straightness, cross section, forking, foliar damage, stem damage, branch angle and self-pruning ability was determined, and it was observed that the variations were very less among the trees located. The total score for the qualitative characters varied from 21 to 48. The values showed that not much variations existed for the qualitative character of the trees and these characters are mostly genetically determined.

Self-pruning ability, cross section, branch angle and thickness were strong indicators of timber quality. For the better growth potential of a tree, a large healthy crown is deeply important. In a study by Binu (2019) and Chauhan *et al*.(2018) in *Melia dubia*, maximum variations were shown for the characters apical dominance and forking. This showed that the trees had better growth and production. Hence, weightage must be given for these traits during selection. Availability of the variability in the population is the raw material in any breeding programme, and the present study revealed that the variability is high. This offers a high opportunity for selecting plus tree with individuals having desirable characteristics.

In the present investigation, thirty candidate plus trees were selected from selected Kerala using a baseline regression system combined with a scoring of qualitative traits. Details of thirty selected CPTs are given in **Table 2**. The variation in tree height was in the range of 20 m (FCV-AT-50) to 37 m (FCV-AT-32). The maximum tree height (37 m) was recorded for FCV-AT-32 while the minimum height (20 m) was recorded for FCV-AT-50. The average tree height measured for the plus trees was 28.07 m. The standard deviation for tree height was 4.76 m and, the coefficient of variation was 16.89 per cent. The variation in girth at breast height was in the range of 0.69 m (FCV-AT-44) to 2.11 m (FCV-AT-48). The maximum GBH (2.11 m) was recorded for FCV-AT-48 and, the minimum (0.69 m) was recorded for FCV-AT-44. The average girth estimated was 1.20 m. The standard deviation and coefficient of variation of GBH were 0.36 m and 29.84 per cent, respectively.

The average crown width for CPTs was 6.41 m and, the variation ranged from 3.5 m (FCV-AT-42), (FCV-AT-43) and (FCV-AT-44) to 9.75 m (FCV-AT- 48). The standard deviation for crown width was 1.93 m and, the coefficient of variation was 30.34 per cent. A wide range of variation is observed in clean bole height, i.e., 7 m (FCV-AT-43) to 24 m (FCV-AT-31) and FCV-AT-40). The average clean bole height for all the CPTs was 17.10 m. The standard deviation and coefficient of variation of clean bole height were 4.20 m and 24.19 per cent, respectively. The selection of plus trees is an essential tool for the genetic improvement of a tree. To make selection effective, Hazel and Lush (1942) stressed the importance of genetic variation present in the population, the heritability of the traits, and the genetic and environmental correlation of each trait with the other. Successful phenotypic selection depends on the amount of genetic variability available in the population for important economic characteristics and their interrelationship (Lone and Tewari, 2008).

Heritability is the second important criterion after variation for selecting the plus trees. Stem straightness and roundness are known to be directly related to wood quality, and even a simple selection of tree shapes can improve the quality and quantity of the product (Shelborne, 1969). In the present study, the qualitative and quantitative characteristics of trees, such as clear bole height, bole shape, and branching pattern were given importance for selecting *Ailanthus triphysa* trees from the natural population.

Plus tree selection is necessary for immediate improvements for seed stands or seed production areas. Therefore, careful selection of plus trees is needed to ensure maximum utilization of genetic variations. Plus tree selection was recorded in several hardwood species which were in line with the current studies. Binu (2019) selected candidate plus trees of *Melia dubia* from different forests of Kerala using a baseline regression system. Dhillon *et al*. (2009) reported candidate plus trees selection of *M. azederach* through baseline method from different agro-climatic areas of Punjab. Similarly, the traits based on apparent growth, clear bole and stem straightness and other traits of priority were selected in different tree species *viz. Azadirachta indica* (Dhillon *et al.,* 2003), *Pongamia pinnata* (Kaushik *et al.,* 2011) *Terminalia chebula* (Navhale *et al*., 2011) and *Salix alba* (Paray *et al*., 2017). Generally, the qualitative characteristics are not taken into account in selecting trees based on the baseline methods. However, in the present study, the qualitative characteristics of the trees were also taken into account to reduce the number of CPTs, thus making it a multistage selection. In the first stage, trees were separated with better quantitative characteristics. In the second stage, the best trees were then chosen according to the qualitative character ranking. This made the selection more robust. However, some trees of higher qualitative characters may not be selected, because the selection primarily depends mainly on baseline fitting. Against this backdrop, selections were made from different panchayaths consisting of two low lands, five midlands and three high lands.

In this study, hierarchical cluster analysis was carried out on the 30 selected plus trees. The thirty plus trees were grouped into nine clusters, as presented in the dendrogram (**Fig. 1**). Trees coming in a cluster have similar morphological characters, whereas it differs between two clusters. Cluster I possess the maximum number of CPTs with 15 accessions whereas the least number was observed for cluster VII, VIII and IX respectively as they contained only one accession. Clusters with only one plus tree can either possess superior or inferior quality among the plus trees.

Table 2.Details of thirty selected plus trees of *Ailanthus triphysa* from different locations

|	Locality	Tree ID	Accession No.	Location	Height (m)	GBH (m)	Crown width (m)	Clean Bole Height (m)
Low lands (Below 7.5 m)	Anthikad	A-10	FCV-AT-21	10°27′58.18″ 076°07′18.44″	25	1.02	7.5	9
		A-12	FCV-AT-22	10°27′57.67″ 076°07′16.96″	22	0.93	6.5	10
		A-19	FCV-AT-23	10°28′03.45″ 076°07′28.32″	26	0.95	6	17
	Manalur	M-05	FCV-AT-24	10°29′58.28″ 076°06′30.33″	25	0.82	7.5	17
		M-10	FCV-AT-25	10°29′57.26″ 076°06′31.15″	23	0.9	4.5	14
		M-21	FCV-AT-26	10°29′55.95″ 076°06′07.81″	25	0.88	4.5	18
Mid lands (Between 7.5 -75 m)	Pudukkad	P-13	FCV-AT-27	10°28′17.86″ 076°18′41.96″	32	1.2	6	16
		P-16	FCV-AT-28	10°28′15.52″ 076°18′46.49″	32	1.15	7.5	24
		P-23	FCV-AT-29	10°28′15.08″ 076°18′44.56″	32	1.1	6	19
	Chalakudy	C-07	FCV-AT-30	10°18′36.52″ 076°18′09.26″	35	1.65	9.5	16
		C-12	FCV-AT-31	10°18′37.01″ 076°18′07.94″	36	2	11	24
		C-25	FCV-AT-32	10°18′54.22″ 076°18′35.88″	37	1.6	9.5	21
	Wadakkanchery	W-06	FCV-AT-33	10°39′54.68″ 076°16′22.07″	31	1.2	5.5	21
		W-16	FCV-AT-34	10°39′59.47″ 076°16′01.58″	32	1.36	6	15
		W-20	FCV-AT-35	10°39′55.62″ 076°16′24.55″	29	1.3	7	16
	Vengara	V-10	FCV-AT-36	11°03′01.45″ 075°57′53.65″	29	1.6	6.5	21
		V-18	FCV-AT-37	11°03′01.24″ 075°57′56.12″	26	1.6	8.5	19
		V-24	FCV-AT-38	11°02′42.06″ 075°56′24.74″	29	1.8	7.5	21
	Parappur	PA-07	FCV-AT-39	11°02′16.91″ 075°59′22.49″	35	1.02	5	23
		PA-16	FCV-AT-40	11°02′08.62″ 075°59′50.68″	31	1.04	7	24
		PA-20	FCV-AT-41	11°01′49.34″ 075°59′51.90″	34	1.1	5	21
High lands (Above 75 m)	Thrikkadeeri	PA-05	FCV-AT-42	10°50′41.79″ 076°22′21.14″	26	0.9	3.5	18
		T-11	FCV-AT-43	10°50′42.31″ 076°22′21.11″	24	0.9	3.5	7
		T-25	FCV-AT-44	10°50′43.30″ 076°22′22.16″	25	0.69	3.5	16
	Ananganadi	AN-10	FCV-AT-45	10°49′59.31″ 076°20′37.29″	25	1.05	4.5	13
		AN-12	FCV-AT-46	10°49′59.42″ 076°20′37.16″	26	1.01	6.5	14
		AN-17	FCV-AT-47	10°49′59.40″ 076°20′37.73″	26	0.97	5	16
	Urakam	U-01	FCV-AT-48	11°03′02.66″ 075°59′22.00″	21	2.11	9.75	14
		U-09	FCV-AT-49	11°03′03.17″ 075°59′42.17″	23	1.12	5.5	17
		U-26	FCV-AT-50	11°02′00.75″ 075°59′55.58″	20	1.16	6.5	12
	Mean				28.17	1.21	6.37	17.38
	Standard Deviation				4.76	0.36	1.93	4.20
	Coefficient of Variation (%)				16.89	29.84	30.34	24.19
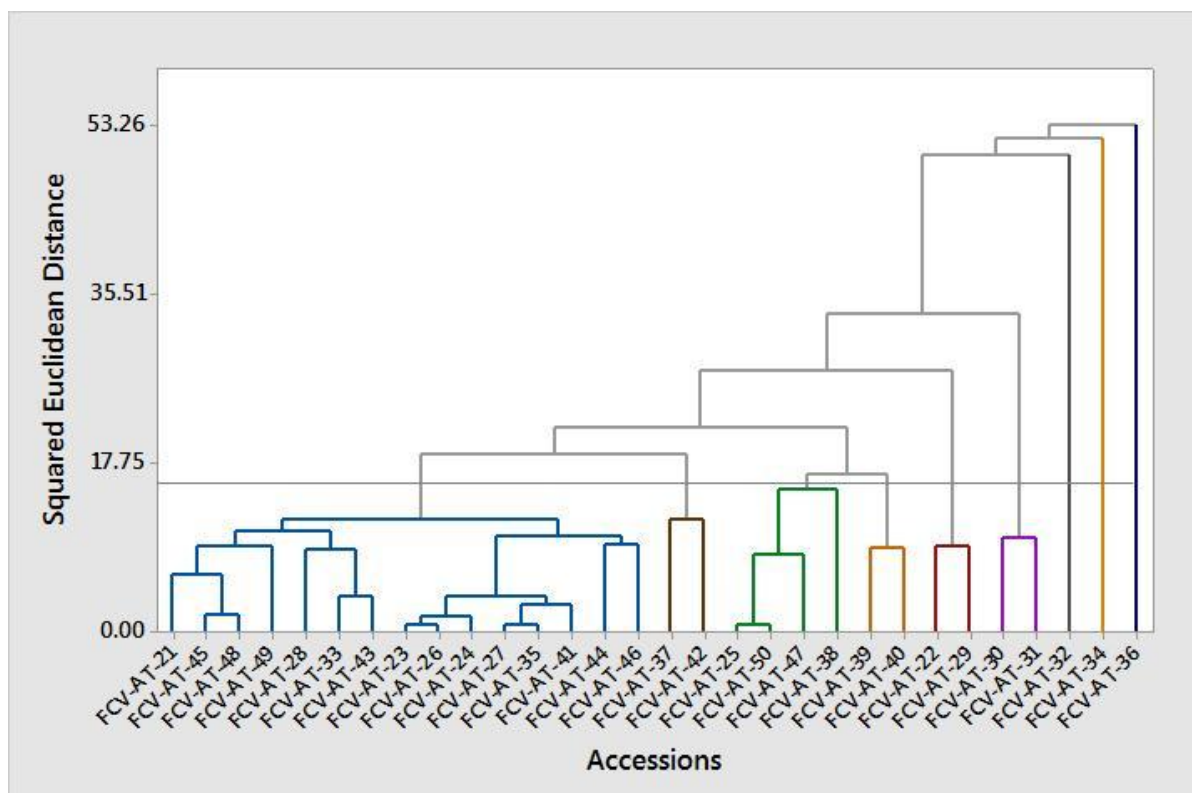
Fig. 1. The dendrogram on morphological characteristics of 30 CPTs of *Ailanthus triphysa*

Table 3. Matrix showing inter and intra cluster distance of *Ailanthus triphysa* based on morphological characters

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX
Cluster I	2.07								
Cluster II	4.12	1.79							
Cluster III	3.34	5.27	1.57						
Cluster IV	4.79	6.28	6.12	1.50					
Cluster V	6.59	7.60	7.45	6.35	1.72				
Cluster VI	6.64	7.76	6.96	6.62	8.91	1.49			
Cluster VII	6.79	7.95	7.05	6.45	8.82	7.92	0.00		
Cluster VIII	3.35	5.08	4.56	4.34	6.45	7.23	7.01	0.00	
Cluster IX	4.02	5.85	3.26	5.77	7.06	7.19	7.12	4.72	0.00

The clustering pattern revealed that plus trees from the same geographic sources were grouped into different clusters while plus trees from different geographic sources were grouped into the same clusters. This showed that the variations in geographic regions were not in line with genetic diversity. These trends of results were obtained by Kaushik *et al.* (2007) in *Jatropha curcas*. The trees from one area were distributed over various clusters.

The intra and inter cluster analysis indicated that the highest intra cluster was observed on cluster I (2.07) followed by cluster II (1.79), cluster V (1.72), cluster III (1.57), cluster IV (1.50) and cluster VI (1.49). The highest inter cluster distance was shown by cluster V and VI (8.91) followed by cluster V and VII (8.82) and cluster II and VII (7.95) (**Table 3**). The maximum intra-cluster distance shown by cluster I indicate greater genetic

distance within the cluster itself which may be due to environmental factors and thus, recommended that the selection of plus trees should be based on genetic diversity rather than geographic diversity. Likewise, the maximum inter-cluster distance was due to environmental factors. The least inter-cluster distance revealed there was low genetic diversity, and selection should be avoided from this cluster. This showed that higher inter-cluster distance should be selected for further improvement, and better progeny can be achieved through hybridization. Therefore, the plus trees belonging to this cluster can be used for the hybridization programme to obtain hybrid vigour and identify the most distant accessions. Several investigations that are in line with the present studies were also recorded for the species such as *Pinus gerardiana* (Kant *et al*., 2006), *Pinus wallichiana* (Aslam *et al*., 2011) and *Melia dubia* (Binu, 2019). This revealed that genetic diversity should be carefully considered to be the main criterion for the selection of plus trees instead of geographic variations.

From the current investigations, high variability for different quantitative and qualitative characters of *Ailanthus triphysa* was recorded. Thus there is a better chance of selecting a plus tree with individuals having desirable characteristics. For any tree improvement programme, the selection of candidate plus trees is essential. Hence, the present findings of CPTs in this study could be useful for the efficient management and exploitation of *Ailanthus triphysa* germplasm in future breeding programmes, and the optimal use and improvement of *Ailanthus triphysa* resources.

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REFERENCES

Abijith, R. 2018. Selection and evaluation of superior planting materials of *Ailanthus triphysa* (Dennst.) in Thrissur. M.Sc. Thesis, Kerala Agricultural University, Thrissur, Vellanikkara.

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

Binu, N. K. 2019. Genetic variability and plus tree selection in natural populations of malaveppu (*Melia dubia* Cav.). Phd. Thesis, Kerala Agricultural University, Thrissur, Vellanikkara.

Chauhan, R. S., Jadeja, D.B., Thakur, N. S., Jha, S. K. and Sankanur, M. S. 2018. Selection of Candidate Plus Trees (CPTs) of Malabar Neem (*Melia dubia* Cav.)

for Enhancement of Farm Productivity in South Gujarat, India. *Int. J. Curr. Microbiol. App. Sci.,* **7**(5): 3582-3592. [Cross Ref]

Das, J. K. 2018. Screening of superior genotypes of *Ailanthus triphysa* (Dennst.) Alston. (Matti) for matchwood quality. M.Sc. Thesis, Kerala Agricultural University, Thrissur, Vellanikkara.

Dhillon, G.P.S., Sidhu, D.S., Singh, B. and Singh, A. 2009. Genetic variation among open pollinated progenies of *Melia azadarach* under nursery and field conditions. *Indian For*., **135**(1): 84-88.

Dhillon, R. S., Bisla, S. S., Arya, S. and Hooda, M. S. 2003. Genetic variation, heritability and correlation for growth parameters in *Azadirachta indica* A. *Juss. Ann. of For*., **11**(2):215-221.

Hazel, L. N. and Lush, J. L. 1942. The efficiency of three methods of selection. *J. Heredity* **33**: 393-399. [Cross Ref]

Jamaludheen, V. K., Gopikumar and Sudhakara, K. 1995. Variability studies in Lagerstroemia (*Lagerstroemia speciosa* Pers.). *Indian For*., **121**(2):137-141.

Jayaraj, R. S. C. 1997. Selection of candidate plus trees of *Eucalyptus* spp. For a large scale clonal forestry programme. In: Vivekanandan, K., Gurumurthi, K., and Jayaraj, R. S. C. (eds.), *Clonal Multiplication of Eucalyptus*. Institute of Forest Genetics and Tree Breeding. pp. 34-37.

Kant, A., Dutt, V. and Sharma, D. R. 2006. Genetic variability in phenotypic characters of *Pinus gerardiana*. *Indian For*., **132**: 681-690.

Kaushik, N., Krishan, K., Sushil, K., Nutan, K. and Roy, S. 2007. Genetic variability and divergence studies in seed traits and oil content of Jatropha (*Jatropha curcas* L.) accessions. *Biomass and Bioenergy* **31**: 497–502.

Kaushik, N., Suman, M. and Krishan, K. 2011. Variability in growth characters among progenies of *Pongamia pinnata* (L.) Pierre. *Range Manag. and Agrofor.*, **32**(2):131-134. [Cross Ref]

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

Lone, A. and Tewari, S. K. 2008. Genetic variability and correlation studies in poplar (*Populus deltoides* Bartr.). *Indian J. For*., **31** (2): 193-196.

Nair, P. N. 1961. Regeneration of moist tropical evergreen forests with special reference to Kerala. Student Thesis. Indian Forest College, Dehradun.

Navhale, V. C., Sonone, N.G., Jangam, P. S., Jadhav, S. T. and Bhave, S. G. 2011. Genetic variability and selection of candidate plus trees in chebulic myrobalan (*Terminalia chebula* retz.). *Electronic Journal of Plant Breeding* **2**(1): 157-163.

Paray, P.A., Gangoo, S.A., Masoodi, T.H., Qaiser, K.N., Islam, A.I. and Maqbool, S. 2017. Selection, variation and heritability of candidate plus trees (CPT's) of *Salix alba*. *Electronic Journal of Plant Breeding*, **8**(3): 779-786. [Cross Ref]

Rudolf, P. O. 1956. *Guide for selecting superior forest trees and stands in the Lake States* (No. 40). Lake States Forest Experiment Station, US Department of Agriculture, Forest Service. 42p. [Cross Ref]

Shelborne, C. J. A. 1969. Breeding for stem straightness in conifers. Doc. Second world Cons. *For. Tree Breed*. **1**: 293-302.

Troup, R. S. 1921. Silviculture of Indian Trees. Clarendon Press. London. **3**: 152. [Cross Ref]