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Effect of age on the growth and physical properties of *Ailanthus excelsa* Roxb.

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Abstract
Ailanthus excelsa Roxb. commonly known as Ardu or tree of heaven is a fast-growing large deciduous tree mainly used as a timber in different end uses. In the present study, total 25 trees were selected from one to five years of Ardu plantations established at Natural Resource Management Farm of Navsari Agricultural University, Navsari to evaluate the effect of age on the tree growth and physical properties of wood. A significant variation was recorded among one to five years old Ardu trees for growth parameters such as GBH (19.40 to 39.28 cm) and tree height (2.52 to 9.00 m); however, bark and wood content were found to be non-significant among five age gradations. Growth pattern of Ardu showed an increasing trend with tree age. Physical properties such as basic density (0.200 to 0.292 g/cm^3) and moisture content (249.49 to 403.53%) varied significantly with tree age and showed inverse relationship with each other. It is concluded that the wood of *A. excelsa* at four or beyond four years of rotations are suitable for various end uses.

Keywords: basic density, moisture content, wood content, bark content

Introduction
Ailanthus excelsa Roxb. commonly known as Ardu or tree of heaven is a large deciduous tree, indigenous to Central and Southern India belonging to the family Simaroubaceae (Kanna *et al*., 2019) [3]. It is a fast-growing tree which can reach a height of 20-24 m and 60 to 80 cm in diameter with wide spreading branch on a stout, straight, tall bole (Manish *et al*., 2007) [4].

The wood of Ardu is white and lustrous, with a light yellowish colour. Its wood is straight grained, fairly even and coarse textured with indistinct annual growth rings. The timber is very light with easy sawing and wood working quality but the wood is perishable and subject to insect attack and blue stain. (Jat *et al.*, 2011) [2]. In India its most important use is as a fodder tree. However, the wood is used in manufacturing of plywood, boxes, crates, poles, fishing floats, tool handles, matches and drums (Jat *et al.*, 2011) [2].

Due to the increasing demand and consumption of structural wood and the continuous development of forest industries, plantation of fast-growing trees became important for sustainability of industrial wood raw material (Elzaki and Khider, 2013) [1]. The basic density and moisture content are important physical properties of wood to know the biomass of tree during their growth for proper end utilization of the species at particular age (Kanna *et al*. 2019; Sinha *et al*. 2019) [3, 9]. Limited research has been carried out on such aspects in *Ailanthus excelsa* trees at different ages (Elzaki and Khider, 2013; Kanna *et al*. 2019) [1, 3]. Hence, the current study was carried out to know the effect of age on the tree growth and physical properties of wood in *Ailanthus excelsa*.

Materials and Methods
For the present investigation, total 25 trees of *Ailanthus excelsa* (Ardu) were selected randomly from one to five years of plantations established at Natural Resource Management (NRM) Farm of the Navsari Agricultural University, Navsari to evaluate the effect of age on the growth characteristics of tree and physical properties of wood. This region belongs to tropical climate characterized by fairly hot summer, moderately cold winter and more humid and warmer monsoon with heavy rainfall. Total five trees were selected for sampling from each age of plantation. Girth of tree was measured at the breast height *i.e.*, 1.37 m from the ground level by using tape and total height of tree was also measured by tape from bottom to the tip of the tree after harvesting and average was worked out from each replicate. The bark and wood percentage were calculated on area basis at the breast height of tree by measuring the radius over bark and under bark.

To evaluate the basic density and moisture content of wood, one-disc sample was collected from each tree at the breast height (DBH) from first, second, third, fourth and fifth years of plantations. Blocks of 2.5 x 2.5 cm^2 cross-section and five centimeters in length were prepared from the fresh disc of each tree and weighed immediately to record the fresh weight. Then, samples were placed in a hot-air oven for drying at a temperature of 103 ± 2 ˚C till constant weight to get the oven-dry weight of samples. The green volume of wood was determined by water displacement method. The moisture content of wood was calculated on the oven-dry basis and basic density of wood was calculated by dividing oven-dry weight of the sample by green volume.

The data of growth and physical parameters generated in the study were subjected to the statistical analysis following completely randomized design (CRD) and analysis of variance (ANOVA) was constructed using the statistical software package developed by Sheoran *et al*. (1998) [8]. Treatment means were compared at $P \leq 0.05$.

Results and Discussion

Growth Parameters

Girth at the breast height (GBH) is one of the important tree growth parameters.

The GBH increased from first year to fifth year. The maximum girth at breast height (39.28 cm) in *A. excelsa* was observed at five years of age and minimum girth at breast height (19.40 cm) was observed at one year of age. An increasing trend was observed in height of the tree from first year to fifth year. The maximum height (9.00 m) of *A. excelsa* was observed at fifth year of age and the minimum height (2.52 m) was observed at one year of age in the current investigation. It was observed that bark percentage varied insignificantly at different ages. The maximum bark percentage (20.70%) in *A. excelsa* was recorded at first year and the minimum bark percentage (15.41%) was recorded at third year of age. Like bark percentage, wood percentage also varied insignificantly at different ages in *A. excelsa*. The maximum wood percentage (84.59%) in *A. excelsa* was reported at one year of age while, minimum wood percentage (79.30%) was recorded at first year. The uniformity in bark and wood content with tree age may be due to the increase in bark thickness with tree age in the more or less similar proportion with increase in stem wood diameter or tree girth (Zobel and Jett, 1995) [10]. Similar trend was also reported by Tewari (2004) [5] in 5-8 years old *Ailanthus excelsa* plantations raised by Forest Department of Pali district in Rajasthan.

Physical Parameters

Basic density of wood is one of the important physical parameters in deciding the characteristics of raw material for proper end use. Maximum basic density (0.292 g/cm^3) of *A. excelsa* was observed at four year and it was found more or less constant at fifth year. The minimum basic density (0.200 g/cm^3) was observed at one year of age. The maximum moisture content (403.53%) in *A. excelsa* was recorded at one year of age followed by second year. The minimum moisture content (249.49%) was recorded at fourth year. Basic density of *A. excelsa* wood significantly increased with increase in tree age from one to fourth year. Moisture content of *A. excelsa* wood significantly decreased from one to fourth year. The result is in agreement with those of Saravanan *et al.* (2013) [6] who recorded that the moisture content of wood decreased with increase in the age of *M. dubia* trees. These results are in the conformity with the findings of Saravanan *et al.* (2014) [7] who reported that basic density of *M. dubia* increased with increase in age. Elzaki and Khider (2013) [1] reported that the average basic density of *Ailanthus excelsa* was 316 kgm^{-3} grown in Western Sudan. The results of the present study signify that the wood of *A. excelsa* at four or beyond four years of rotations are suitable to meet the demand of forest industries for various end applications such as plywood, match boxes and splints, drums, pulp and paper etc.

Table 1: Effect of age on the growth parameters of *A. excelsa* (Mean±SD)

Age of tree	GBH (cm)	Height (m)	Bark %	Wood %
One year	19.40 ± 3.63	2.52 ± 0.62	20.70 ± 4.50	79.30 ± 4.51
Two years	19.62 ± 1.49	4.86 ± 0.35	17.76 ± 3.82	82.24 ± 3.82
Three years	24.40 ± 4.07	7.09 ± 1.21	15.41 ± 3.12	84.59 ± 3.12
Four years	27.62 ± 5.03	7.10 ± 1.22	15.98 ± 2.03	84.02 ± 2.03
Five years	39.28 ± 6.99	9.00 ± 1.20	16.44 ± 4.19	83.56 ± 4.19
S.Em. (±)	2.06	0.44	1.63	1.63
C.D. at 5%	6.08	1.30	NS	NS

Table 2: Effect of age on the physical properties of *A. excelsa* (Mean±SD)

Age of tree	Moisture content (%)	Basic density (g/cm^3)
One year	403.53 ± 112.48	0.200 ± 0.045
Two years	302.97 ± 43.99	0.260 ± 0.022
Three years	299.85 ± 22.46	0.274 ± 0.021
Four years	249.49 ± 93.03	0.292 ± 0.056
Five years	263.98 ± 49.72	0.288 ± 0.043
S.Em. (±)	32.38	0.02
C.D. at 5%	95.53	5.38

Conclusions

The present study corroborates that girth and height of *Ailanthus excelsa* increased significantly at one to five age gradations. The basic density of *A. excelsa* wood significantly increased from one to fourth year of age while, moisture content of wood significantly decreased up to fourth year and then remained more or less constant at fifth year. It signifies that the wood of *A. excelsa* at four or beyond four years of rotations are suitable for various end uses.

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