Original Research Article

VARIATIONS IN GROWTH, WOOD BASIC DENSITY AND FIBER CHARACTERS IN SELECTED CLONES OF *ACACIA AURICULIFORMIS* A.CUNN. EX BENTH

ABSTRACT

The study aimed to screen and shortlist superior *Acacia auriculiformis* clones for desirable growth and wood properties. Twenty clones stem volume, wood basic density and fibre characters were studied at age of four. Significant variations were recorded in tree volume and wood properties among the clones, the stem volume of the clones was ranging from 0.022 to 0.073 m^3 and the maximum tree volume was noticed in clones IFGTBAA 7 and followed by IFGTBAA 27 and 18, the studied clones average stem volume was 0.039 m^3. The average wood basic density of the clones was 469 kg/m^3 and this trait was ranging from 406 to 509 $kg/m^{3.}$ The screened *A. auriculiormis* clones average fibre length was ranging from 785.4 µm to 1140.6 µm and a maximum fibre length above 1000 µm was recorded in clones IFGTBAA 18, 23, 26 and 62. The average Runkel Ratio of all the clones was 0.91 and it was ranging from 0.7 to 1.1. There was no significant positive correlation noticed between growth, wood basic density and fibre properties except stem volume and fibre lumen diameter. Hence, it was decided to select superior clones, IFGTB 7,18,20,23 and 27 based on combined traits of Stem Volume, Wood Basic Density and Fibre Length to establish large scale commercial pulp wood plantations and clones which were having higher density and fibre properties had scope to utilize as parents in *A. auriculiformis* improvement programme to enhance tree volume and wood quality.

Keywords: *Acacia auriculiformis*, improvement, tree volume, wood basic density, fibre properties

Introduction

The practice of sustainable forestry has become the greatest ever challenge to foresters to meet the large array of timber and forest-based demand across the globe. Eventually, Trees outside Forests (TOF), as a result of this, has been a breakthrough to the vast forest utilization activities in India. India being the second most populated nation in the world, TOF meets the livelihood of millions of people by providing sustainable income and generation of employment. The industries like timber, paper, pulp, plywood, match and pencils are being dependent on their raw materials from TOF and import of wood from other countries. Thus, the selection of tree species which tolerates biotic and abiotic stresses and is suitable for varied environment is very important for large scale afforestation programmes. The organized wood-based industries in the country alone need 152 million m^3 of wood to meet the raw material demands during the year 2020 (FAO, 2009) and the firewood requirement of the country is also increasing at an alarming rate. This has created a huge gap between the projected demand and supply of timber products. Government initiatives like development of 100 smart cities, housing for all by 2020, anticipate the growth of tourism, real estate, railways, and defence and furniture industries warrant additional wood requirements. The estimated average productivity of timber in India is 0.7/m^3/ha/year compared to the world average of 2.1/m^3/ha/year. An increase in the total area under tree cover is largely limited, whereas an increment in the productivity per hectare per year is possible through the cultivation of improved clones/varieties by the farming communities on a large scale basis. Hence, it is the need of the hour to develop tree improvement strategies to enhance the productivity and quality of the wood to face the growing challenges against wood demand.

High productive and fast-growing tree species are being planted globally to supply the growing demand for solid wood products and pulp and paper manufacturing (Espinoza 2004). *Acacia auriculiformis* is a fast-growing multipurpose tree species that grows naturally in Australia, Papua New Guinea and Indonesia (Pinyopusarerk *et al*., 1991). It is commercially planted in Malaysia, Vietnam, India, Zaire, Tanzania, and Nigeria (Shukla *et al.,* 2007; Hai. P, 2009). *A. auriculiformis* was introduced in India in west Bengal (Bulgannawar and Math, 1991). It has been successfully raised in West Bengal, Bihar and Andhra Pradesh, Karnataka, Orissa, Uttar Pradesh and Maharashtra. It is a small to medium-sized tree species which grows up to a height of 30 m with a trunk diameter of up to 60 cm in natural stands (Phi, 2009; Ismail *et al*., 2012). The species is used to provide shade from windbreaks and reduce soil erosion in agroforestry systems. The wood is heavy, with a high percentage of heartwood that is quite durable and the heartwood is straightgrained, light brown to dark red in colour. It is used for making round wood, building poles, light construction, flooring, industrial and domestic wood ware, woodcarvings, turnery, furniture, composite boards, wood cement, fuelwood and charcoal (Pinyopusarerk, 1990). It also is suitable for chips, pulp, paper, plywood and fibreboard (Pinso and Nasi,1991). The bark contains tannins that have great scope for utilizing as a natural dye in textile industries. The species was also found useful for the feeding of lac insects, erosion control, soil improvement, restoration of degraded land and ornamental purpose.

Knowledge of the magnitude of the variation is a prerequisite for the genetic improvement of any crop species (Sharma *et al*., 1994). The exploitation of variations is an important step in the genetic improvement of any tree species. The knowledge on variation in growth, wood density and wood anatomical structure is an important factor to screen high productive clones and assess the suitability of the wood for the type of end-product. Exploration of wood end uses could be decided based on variation in growth characters, density and anatomical structure of the wood. Variations in growth traits were recorded in various provenances of *Albizia lebbeck* (Thakur *et al.*, 2014) and seed sources of *Acacia catechu* (Srivastava, 2011). Similar clonal variations were also recorded in Eucalyptus (Vennila, 2009) and Casuarina (Parthiban *et al*., 2018). Variations in growth and fibre characters are the basis for the effective utilization of wood in various end-uses. The wood properties in *A. auriculiformis* have been studied with only a few basic wood properties (Verghese *et al.,* 1999; Ishiguri *et al.,* 2004; Shukla *et al.,* 2007). However, a comprehensive study on growth, density and fibre property variability has not yet been determined in clones. The main objective of this study was to investigate the clonal variation in growth and wood properties of *A. auriculiformis* in Tamil Nadu. India.

Materials and Methods

A systematic tree improvement programme of *A. auriculiformis* was initiated at the Institute of Forest Genetics and Tree Breeding, Coimbatore, India during 1996 by introducing first-generation breeding population with 1030 trees bulked with seed lots of various provenances from CSIRO, Australia and evaluation was completed during 2000. The progeny trial evaluation identified 20 potential seed lots from second-generation progeny trials that were located at Panampilly (10°47'15.5"N 76°45'46.4"E), Nilambur (11° 16' 40.2096'' N76° 14' 34.2744'' E), Wadakkanchery (10° 39' 28.2276'' N 76° 14' 29.9544'' E) and Palode (8° 44' 6.3924'' N, 77° 3' 18.3996'' E) in Kerala(Figure 1). Twenty clones of *A. auriculiformis* were multiplied at the vegetative propagation complex using coppice shoot cuttings collected from selected clones. The details on the origin of the clones are presented in Table 1. The clonal evaluation trial of *A.* auriculiformis was established with 20 clones at IFGTB-Field Research Station, Neyveli, Cuddalore, Tamil Nadu during 2014. The clones were planted at an espacement of 3 m × 3 m in Row Column Design with four replications and each replication consisted of four ramets.

The study site is located in Cuddalore District, Tamil Nadu, India and lies between the latitude of 11°54’32” N and the longitude of 79°47’60” E. The altitude is 87 MSL and it receives an annual rainfall of about 900 mm, a mean maximum summer temperature (April–June) of 36.7°C and a mean minimum temperature (December–February) of 7.5°C (2005–06). The topography is almost flat, with red sandy loam soil. The clonal trial of *A. auriculiformis* was evaluated for growth parameters and wood traits during 2019. The data on height, Girth at Breast Height (GBH) and diameter were collected and the volume was calculated as per the method suggested by Huong (2020). Standing volumes were calculated as:

$V = \pi(D/200)^2 * H * .F$, where V is the stem volume in m^3, D is DBH in cm, H is total height in m and F is a form factor (0.475) (Panwar and Bhardwaj, 2005). The core wood samples were extracted at 1.37 m height from the base in the north-south direction. Samples were considered for anatomical studies *viz.,* fibre length, fibre diameter, wall thickness and specific gravity. These samples were cut into small pieces with a razor blade and placed in test tubes containing Hydrogen peroxide (H_2O_2), water and glacial acetic acid in the ratio of 1:4:5 followed by maceration (Peterson *et al*., 2008). After that the 20 (µm) transverse sections of the core samples were put into a test tube and kept in a hot water bath at 70 ºC for 12-18 hours, the samples turn into white colour macerated form from yellow colour. Macerated samples were prepared with sliding and then stained with safranin, dehydrated in a graded ethanol series and mounted on glass slides. Photomicrographs taken with a digital live camera (Nikon eclipse Ci) mounted on a microscope were used for measuring fibre length, fibre diameter and fibre wall thickness measured for 30 fibres at each clone using NIS elements software. The pulp and paper quality can be estimated using the following indices: Runkel ratio (Runkel, 1949), Luce’s shape factor (Luce, 1970), flexibility coefficient (Malan and Gerischer, 1987), slenderness ratio (Malan and Gerischer, 1987), solids factor (Barefoot *et al.,* 1964) and wall coverage ratio (Hudson *et al*., 1998). The formula for calculation of pulp and paper quality derived indices is given below in chart.

Chart 1: The formula for calculation of pulp and paper quality derived indices

Fibre derived indices	Related pulp and paper properties	Formula	Reference
Runkel ratio	Pulp yield (positively) and digestibility (negatively)	(2×FWT)/FLD	Runkel (1949)
Luce's shape factor	Resistance to beating (positively)	$(FD^2-FLD^2)/(FD^2+FLD^2)$	Luce (1970)
Flexibility coefficient	Tearing and tensile strength (positively)	FLD/FD	Malan and Gerisher (1987)
Slenderness ratio	Tearing strength (positively)	FL/FD	Malan and Gerisher (1987); Ona *et al*., (2001)
Solids factor	Sheet density (negatively)	$(FD^2-FLD^2)\times FL$	Barefoot *et al*., (1964); Ona *et al*., (2001)
Wall coverage ratio	Bending resistance (negatively)	(2×FWT)/FD	Hudson *et al*., (1998)

Note: FWT; fiber wall thickness, FLD; fiber lumen diameter, FD; fiber diameter, FL; fiber length.

The descriptive statistical analysis for each parameter was carried and the analysis of variance (ANOVA) was worked out using the SPSS version 25 software.

Results and Discussion

General Growth Characteristics

The clonal evaluation trial exhibited significant variation among the clones due to growth attributes and the results are furnished in Table 1. Among the twenty *A. auriculiformis* clones tested, it was found that the Height, GBH and DBH of the clones varied significantly (Table 2). The highest value of GBH was recorded in the clone IFGTBAA 7 (39.67 cm) followed by IFGTBAA 27 (39.00 cm) and the lowest value of GBH of 28.42 cm was recorded in IFGTB AA 26. Analogous to this, clone IFGTBAA 7 (12.19 m) and IFGTBAA60 (9.52 m) recorded the highest value for height and the clone IFGTBAA26 recorded the lowest value for height (7.28 m). Clone IFGTBAA 7 (0.48 m^3) yielded the maximum volume and the lowest volume was yielded by the clone IFGTBAA 26 (0.14 m^3). The results of the present study indicate that the clone IFGTBAA 7, 27 and 18 were superior over the other clones in the growth characteristics. However, the existence of any trend between height and GBH could not be elucidated. This outcome agrees with the results in acacia hybrid clones and pure species as controls in northern Vietnam reported by Kha (2001) In general, the GBH is considered as a better indicator of growth and many biomass estimation equations prefer to use girth and height or girth alone but not the tree height (Bastien Henri *et al.*, 2010). The survival percentage of different clones varied from 31.00 % to 89.10 %. The highest survival percentage was recorded in IFGTBAA 26 (89.50 %), followed by IFGTBAA 18 (82.3 %) and IFGTBAA 7 (81.30 %) whereas lowest survival percentage in IFGTBAA 42 (31 %). The survival percentage of the Acacia species irrespective of provenances and sites had also been previously reported by Atipanumpai (1989) and Vincelette *et al.,*(2007).

Wood basic density

The density of wood is considered as the best single index for overall wood quality as well as pulp yield and quality (Bendtsen, 1978). Significant variations were recorded among *A. auriculiformis* clones for wood density and it ranged from 0.406 gcm^{-3} to 0.579 gcm^{-3}. The highest wood density was found in IFGTBAA 1 followed by IFGTBAA 60, IFGTBAA 18 and IFGTBAA 19 (Table 3). The higher wood density of *A. auriculiformis* clones can also be inferred from the results of a study in a 5 year old clonal trial of this species with an average wood density of forty clones was 520 kg m^{-3} for heartwood and 560 kg m^{-3} for sapwood in southern Vietnam (Hai *et al.,* 2009). The present results also confirm the finding of Khasa *et al*., (1995) who observed significant differences in basic density between *A. auriculiformis* provenances.

Fibre Dimensions Characteristics

The fibre wall thickness, fibre length, fibre diameter and fibre lumen diameter of the *A. auriculiformis* clones have recorded significant variations among the clones ($p < 0.01$) (Table 4). The fibre wall thickness of the clones varied from 8.40 µm in clone IFGTBAA 46 to 10.70 µm in clone IFGTBAA 18. The clones which yielded greater volume have recorded twice the fibre wall thickness as compared to that of clone IFGTBAA 60. Fibre wall thickness, being a direct indicator of poor bursting strength, tensile strength and folding resistance of the paper, is an important factor while considering the best clone for pulping (Clarke, 1962). Lowest fibre wall thickness of the clones IFGTBAA 34 and IFGTBAA 27 further indicates that these clines may yield more juvenile wood and are hence, suitable for pulping.

The fibre lumen diameter determines the beating quality of pulp and it varied among the clones significantly from 9.40 µm to 14.10 µm. The higher values were found in IFGTBAA 7 (14.10 µm) and IFGTBAA 4 (14.10 µm) followed by IFGTBAA 1 (13.00 µm) and IFGTBAA 30 (9.40 µm) recorded a lower value for fibre lumen diameter. Long fibres are more suitable for the manufacture of paper as it yields paper with greater resistance against tearing and a more open sheet structure (Wimmer *et al*., 2002; Bhat *et al*., 1989). The fibre length of *A. auriculiformis* clone IFGTBAA 23 (1140.60 µm) followed by IFGTBAA 18 (1082.90 µm) showed comparatively higher values than the values recorded in the same species were 1060 µm and 879 µm by Chowdhury *et.al.,* (2009) and Chong *et.al.,* (2013) respectively. The clones IFGTBAA 27 and IFGTBAA 34 also recorded comparable lumen diameter and fibre length as compared to the maximum values.

Runkel ratio refers to the conformability and collapsibility of fibres and pulp yield (Dutt and Tyagi, 2011).The Runkel ratio of thin walled fibre is < 1.0 and it is suitable for pulp making (Runkel, 1949). Fibres with more than a 1.0 Runkel ratio are stiffer and more difficult to collapse and are used to make bulkier paper (Sharma et al. 2013). In the present study, four Acacia clones had the Runkel ratio value greater than 1 and the ratio varied from 0.69 to 1.13. The acacia clone IFGTBAA 7 (0.69) and IFGTBAA 4 (0.78) had the lowest Runkel ratio values. The recorded Runkel ratio values of acacia clones are lower than reported Runkel ratio values of *L. leucocephala*, (Malik *et al*., 2004) *E. tereticornis* and *Casuarina equisetifolia* (Chaudhari *et al*., 2017). Hence the acacia clones are more suitable for paper and pulp making.

Luce's shape factor is used to estimate the capacity of fibres that tend to collapse and it is the measures of the density and the breaking length of the paper sheet (Luce, 1970). The Luce's shape factor with a lower value is an indicator of decreased resistance of pulp to beating (Luce 1970). Luce's shape factor value is varied from 0.47 in IFGTBAA 7 to 0.63 in IFGTBAA 30 (Table 5). However, the luce's shape factor recorded by other clones was almost on par. The results are in confirmation with the findings of Pirralho *et al*., (2014) recording Luce'shape factor ranging from 0.39 to 0.74 in several Eucalyptus species, 0.41 in *Leucaena leucocephala* is reported by Oluwafemi and Sotannde (2007) and 0.26 in *Ricinodedron heudelotii* reported by Mercy *et al*., (2017).

The strength of the paper depends on the flexibility coefficient of the fibre. Higher values indicate the high tensile and bursting strength of paper (Pirralho *et al*., 2014; Takeuchi *et al*., 2016). The acacia clones did not exhibit large variations in the flexibility coefficient. The data depicts that clone IFGTBAA 7 recorded the maximum flexibility coefficient of 59.90 and a minimum of 0.47 in IFGTBAA 30 and it indicates fiber of strength acacia clones are suitable for papermaking. These findings indicate that flexibility coefficient values of *A. auriculiformis* clones are in accordance to many species being used in the paper and pulp industry (Oluwafemi and Sotannde 2007; Chaudhari *et al*., 2017).

The slenderness ratio is directly correlated to the folding endurance of paper (Ona *et al*., 2001) as well as to the tearing resistance (Mabilangan and Estudilo, 1996). Because the accepted standard value of slenderness ratio is 33 (Xu *et al*., 2006), every acacia clone in the present study recorded a ratio higher than 33. Hence, these clones can be used for the production of bulkier papers. Better pulping mechanisms may also lead to the production of good quality paper from these clones. Findings are in conformity with the results of Ohshima *et al*., (2005) reported slenderness ratio of *Eucalyptus globulus* ranging from 50.50 to 56.70.

The properties associated with the physical resistance of a paper are decided by the rigidity coefficient. Wall fraction is also a parameter that determines the degree of conformability within the paper sheets. Lower the values of rigidity coefficient and wall fraction higher the tendency of fibre to collapse, the higher is the degree of conformability within the paper sheets and lesser is the tendency to flocculate in head box. The results of the present study revealed that the rigidity coefficient of all the clones recorded no variation. The clones, namely IFGTBAA 1, 4, 7, 27 and 34 recorded a rigidity coefficient of 0.4 and the remaining clones recorded a value of 0.50. The wall fraction was found to be highest in IFGTBAA 30 (52.10) and was the lowest in IFGTBAA 7 (40.30) followed by IFGTBAA 27 (42.00) and IFGTBAA 7 (42.30). The recorded values of rigidity coefficient and wall fraction were lower than that of these values recorded by Dutt *et al*., (2004 b) in Bamboo (0.59 and 59, respectively) and *Eulaliopsis binata* (0.93 and 59, respectively).

The wall coverage ratio is related to fibre flexibility and bending resistance. A material with a wall coverage ratio value of less than 0.40 is considered as good pulpwood (Kami parupu gijutsu kyokai, 1969). The wall coverage ratio varied significantly and it ranged from 0.17 to 0.97. The lowest wall coverage ratio of 0.17 was recorded in IFGTBAA 51 followed by 0.27 in IFGTBAA60 and the highest wall coverage ratio of 0.95 was recorded in IFGTBAA42. The acacia clones IFGTBAA 51, IFGTBAA 60, IFGTBAA 27, IFGTBAA 18, and IFGTBAA 2 which had a lower wall coverage ratio (<0.30) can be recommended as superior clones for higher pulping properties. Considerable variations in wood properties among the clones will provide an opportunity to select trees for tree breeding programmes to improve the wood quality of this species.

Correlation between growth and wood traits

A. auriculiformis clones were studied using Karl Pearson's simple correlation method. The correlation matrix revealed that growth wood density and fiber properties had significant correlations of varying magnitude and directions among themselves. The traits such as stem height, dbh, stem volume, wood basic density, fiber length, fiber width, lumen diameter and double wall thickness showed significantly both positive and negative correlations. The total height exhibited highly positive correlation with volume (r = 0.97) followed by DBH (r = 0.85) at 0.01 % level of significance and the lumen diameter also were found positively correlated (r =

0.489) at 0.05 % level of significance (Table 5) DBH showed positive correlation with volume (r = 0.94), and whereas the tree volume registered positive correlation with lumen diameter (r = 0.49), at 0.01 % and 0.05 % level of significance respectively. Tree volume is a cumulative function of tree height and DBH. Both height and DBH had registered a positive correlation with tree volume thus revealing a reliable selection parameter. The present findings are similar to the results of Khosla *et al.* (1985) in *Pinusrox burghii*, Sharma *et al.* (1990) in *Glaucium flavum*, Dhillon *et al.* (1995) in *Dalbergia sissoo*, Rawat (2006) in *Pinuswalli chiana*. Gautam (2006), Sharma and Bakshi (2014) in *D. sissoo*, also reported positive correlation for growth characteristics. Moreover, the fiber width exhibited a highly significant positive correlation with lumen diameter (r = 0.946) and double wall thickness at 0.01 % level of significance. The characteristics such as wood basic density, fiber length and fiber length register neither positive nor negative with any other characters studied.

Conclusion

The present study has shortlisted the superior clones of *A. auriculiformis* with higher wood productivity and pulping properties. Though the species can be classified as an elastic fibre yielding species, it was found that the clones which yielded maximum volume recorded greater fibre wall thickness which can be attributed to the speedy maturation of the juvenile wood or other environmental factors. Hence based on superiority in growth and fiber characters, it is concluded that the IFGTBAA 7, IFGTBAA 27 and IFGTBAA 18 may be utilised for large scale plantation programme and also be used as parents in hybridisation programme for improving wood productivity and quality.

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Figure 1: Geographical location of second generation progeny trials at Panampally, Kerala and clone trial at Neyveli, Tamil Nadu

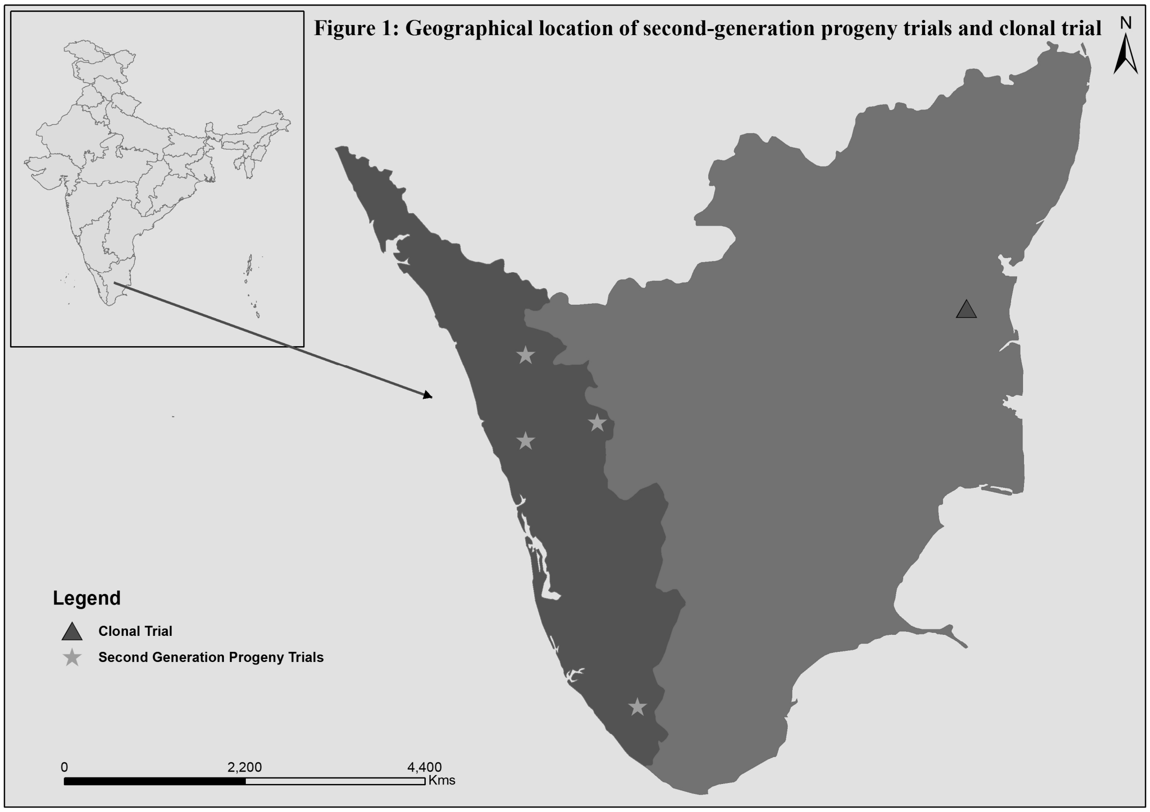

Table 1. Details on origin of *Acacia auriculiformis* clones

S NO	Clone CODE	Pedigree	Source	Geographical coordinates	
				Latitude	Longitude
1	IFGTBAA 1	RI90/3(R5 C8)	SGPANAMPALLY	10°47'15.5"N	76°45'46.4"E
2	IFGTBAA 2	RI90/1	SGPANAMPALLY	10°47'15.5"N	76°45'46.4"E
3	IFGTBAA 4	RI37/3(C15)	SGPANAMPALLY	10°47'15.5"N	76°45'46.4"E
4	IFGTBAA 7	RV87/1(R1 C4)	SGPANAMPALLY	10°47'15.5"N	76°45'46.4"E
5	IFGTBAA 18	RVI119/1	SGPANAMPALLY	10°47'15.5"N	76°45'46.4"E
6	IFGTBAA 19	RII129/4	SGPANAMPALLY	10°47'15.5"N	76°45'46.4"E
7	IFGTBAA 20	RI113/3	SGPANAMPALLY	10°47'15.5"N	76°45'46.4"E
8	IFGTBAA 23	RIII95/3	SGPANAMPALLY	10°47'15.5"N	76°45'46.4"E
9	IFGTBAA 26	2	SGNILAMBUR	11° 16' 40.2"N	76° 14' 34.2"E
10	IFGTBAA 27	3	SGNILAMBUR	11° 16' 40.2"N	76° 14' 34.2"E
11	IFGTBAA 28	4	SGNILAMBUR	11° 16' 40.2"N	76° 14' 34.2"E
12	IFGTBAA 30	6	SGNILAMBUR	11° 16' 40.2"N	76° 14' 34.2"E
13	IFGTBAA 34	10	SGNILAMBUR	11° 16' 40.2"N	76° 14' 34.2"E
14	IFGTBAA 42	RI111/1	SGPALLODE	8° 44' 6.3"N	77° 3' 18.3"E
15	IFGTBAA 46	RI46/3	SGPALLODE	8° 44' 6.3"N	77° 3' 18.3"E
16	IFGTBAA 51	RIV58/3	SGPALLODE	8° 44' 6.3"N	77° 3' 18.3"E
17	IFGTBAA 54	RII52/3	SGWADAKANCHERY	10° 39' 28.2"N	76° 14' 29.9"E
18	IFGTBAA 59	RIII4/2	SGWADAKANCHERY	10° 39' 28.2"N	76° 14' 29.9"E
19	IFGTBAA 60	RII83/4	SGWADAKANCHERY	10° 39' 28.2"N	76° 14' 29.9"E
20	IFGTBAA 62	RIII118/4	SGWADAKANCHERY	10° 39' 28.2"N	76° 14' 29.9"E

Table: 2. Mean performance of growth parameters, wood base density and survival rate in clones of *Acacia auriculiformis*

S.No.	Clone ID	Height (m)	DBH (cm)	Stem Volume (m^3)	Wood Basic Density (kg/m^{-3})	Survival Percent (%)
1	IFGTBAA 1	8.90±0.71	10.85±0.86	0.03±0.00	509.00±46.32	41.70
2	IFGTBAA 2	8.11±0.64	10.48±0.83	0.03±0.00	424.00±33.92	48.00
3	IFGTBAA 4	8.74±0.69	11.20±0.89	0.04±0.00	488.00±39.04	72.50
4	IFGTBAA 7	12.19±0.97	12.63±1.01	0.07±0.00	406.00±32.48	81.30
5	IFGTBAA 18	9.25±0.74	11.86±0.94	0.04±0.00	493.00±39.44	82.30
6	IFGTBAA 19	7.79±0.62	10.35±0.82	0.03±0.00	493.00±39.44	57.30
7	IFGTBAA 20	8.98±0.71	11.35±0.90	0.04±0.00	485.00±38.8	75.25
8	IFGTBAA 23	9.21±0.73	11.62±0.92	0.04±0.00	491.00±39.28	89.50
9	IFGTBAA 26	7.28±0.58	9.05 ±0.72	0.02±0.00	438.00±35.04	32.00
10	IFGTBAA 27	9.28±0.74	12.42±0.99	0.05±0.00	486.00±38.88	60.25
11	IFGTBAA 28	7.31±0.58	9.36±0.74	0.02±0.00	469.00±37.52	64.70
12	IFGTBAA 30	8.54±0.68	10.91±0.87	0.03±0.00	491.00±39.28	72.00
13	IFGTBAA 34	9.128±0.73	11.51±0.92	0.04±0.00	420.00±33.60	56.30
14	IFGTBAA 42	8.42±0.67	10.85±0.86	0.03±0.00	425.00±34.00	31.00
15	IFGTBAA 46	7.39±0.59	10.27±0.82	0.02±0.00	459.00±36.72	55.30
16	IFGTBAA 51	8.26±0.66	10.82 ± 0.86	0.03±0.00	482.00±38.56	39.20
17	IFGTBAA 54	8.252±0.66	10.74 ± 0.85	0.03±0.00	495.00±39.60	65.00
18	IFGTBAA 59	7.91±0.63	10.42 ± 0.83	0.03±0.00	488.00±39.04	64.90
19	IFGTBAA 60	9.52±0.76	10.94 ± 0.87	0.04±0.00	499.00±39.92	56.30
20	IFGTBAA 62	8.18±0.65	10.48 ±0.83	0.03±0.00	443.00±35.44	48.00

Table: 3. Mean performance of **fibre morphology and Runkel ratio** in clones of Acacia auriculiformis.

S.No.	Clone ID	Fiber Length	Fiber Width	Lumen Diameter	Double Wall Thickness	Runkel Ratio
1	IFGTBAA 1	889.60±71.16	22.70±1.81	13.00±1.04	9.70±0.77	0.82±0.06
2	IFGTBAA 2	893.70±71.49	20.50±1.64	10.90±0.87	9.70±0.77	0.93±0.07
3	IFGTBAA 4	921.60±73.72	24.30±1.94	14.10±1.12	10.20±0.81	0.78±0.06
4	IFGTBAA 7	866.40±69.31	23.60±1.88	14.10±1.12	9.50±0.76	0.69±0.05
5	IFGTBAA 18	1082.90±86.62	23.40±1.87	12.70±1.01	10.70±0.85	0.89±0.07
6	IFGTBAA 19	930.70±74.45	21.00±1.68	10.90±0.87	10.00±0.80	0.96±0.07
7	IFGTBAA 20	922.70±73.81	20.10±1.60	10.10±0.80	10.00±0.80	1.04±0.08
8	IFGTBAA 23	1140.60±91.24	19.40±1.55	10.00±0.80	9.40±0.75	0.99±0.07
9	IFGTBAA 26	10210±81.68	20.40±1.63	10.70±0.85	9.70±0.77	0.94±0.07
10	IFGTBAA 27	945.60±75.64	20.70±1.65	12.00±0.96	8.70±0.69	0.75±0.06
11	IFGTBAA 28	985.70±78.85	20.00±1.60	11.00±0.88	9.00±0.72	0.87±0.06
12	IFGTBAA 30	982.50±78.60	19.50±1.56	9.40±0.75	10.10±0.80	1.13±0.09
13	IFGTBAA 34	917.10±73.36	20.60±1.64	11.50±0.92	9.20±0.73	0.83±0.06
14	IFGTBAA 42	785.40±62.83	20.60±1.64	11.10±0.88	9.50±0.76	0.90±0.07
15	IFGTBAA 46	799.90±63.99	18.70±1.49	10.30±0.82	8.40±0.67	0.86±0.08
16	IFGTBAA 51	856.60±68.52	18.80±1.50	9.50±0.76	9.30±0.74	1.03±0.08
17	IFGTBAA 54	953.10±76.24	18.80±1.50	9.50±0.76	9.20±0.73	1.02±0.08
18	IFGTBAA 59	952.50±76.20	20.70±1.65	10.90±0.87	9.80±0.78	0.99±0.07
19	IFGTBAA 60	904.40±72.35	18.20±1.45	9.60±0.76	8.60±0.68	0.94±0.07
20	IFGTBAA 62	1077.20±86.17	21.00±1.68	11.30±0.90	9.60±0.76	0.90±0.07

S.No	Clone ID	Luce's Shape Factor	Flexibility Coefficient	Slenderness Ratio	Rigidity Coefficient	Wall Fraction
1	IFGTBAA 1	0.52±0.04	56.3±4.50	40.30±3.22	0.40±0.03	43.70±3.49
2	IFGTBAA 2	0.57±0.04	52.50±4.2	44.90±3.59	0.50±0.04	47.50±3.80
3	IFGTBAA 4	0.50±0.04	58.00±4.64	38.60±3.08	0.40±0.03	42.00±3.36
4	IFGTBAA 7	0.47±0.03	59.90±4.79	38.20±3.05	0.40±0.03	40.30±3.22
5	IFGTBAA 18	0.55±0.04	53.70±4.29	47.50±3.8	0.50±0.04	46.30±3.70

Table : 4 Variations in the fibre derived indices in clones of *Acacia auriculiformis*

6	IFGTBAA 19	0.57±0.04	51.90±4.15	44.80±3.58	0.50±0.04	48.10±3.84
7	IFGTBAA 20	0.60±0.04	50.00±4.00	46.90±3.75	0.50±0.04	50.00±4.00
8	IFGTBAA 23	0.58±0.04	51.30±4.10	59.9±4.79	0.50±0.04	48.70±3.89
9	IFGTBAA 26	0.57±0.04	52.20±4.17	50.9±4.02	0.50±0.04	47.80±3.82
10	IFGTBAA 27	0.50±0.04	57.70±4.61	46.4±3.72	0.40±0.03	42.30±3.38
11	IFGTBAA 28	0.54±0.04	54.70±4.37	50.3±4.02	0.50±0.04	45.30±3.62
12	IFGTBAA 30	0.63±0.05	47.90±3.83	51.00±4.08	0.50±0.04	52.10±4.16
13	IFGTBAA 34	0.53±0.04	55.30±4.42	45.50±3.64	0.40±0.03	44.70±3.57
14	IFGTBAA 42	0.55±0.04	53.80±4.30	38.80±3.10	0.50±0.04	46.20±3.69
15	IFGTBAA 46	0.54±0.04	54.40±4.35	44.40±3.55	0.50±0.04	45.60±3.64
16	IFGTBAA 51	0.59±0.04	50.30±4.02	47.10±3.76	0.50±0.04	49.70±3.97
17	IFGTBAA 54	0.59±0.04	50.60±4.04	52.90±4.23	0.50±0.04	49.40±3.95
18	IFGTBAA 59	0.57±0.04	51.80±4.14	47.70±3.81	0.50±0.04	48.20±3.85
19	IFGTBAA 60	0.57±0.04	52.40±4.19	50.60±4.04	0.50±0.04	47.60±3.80
20	IFGTBAA 62	0.55±0.04	53.60±4.28	52.50±4.20	0.50±0.04	46.40±3.71

Table: 5. Correlation between growth and wood properties *Acacia auriculiformis* clones

	Ht	DBH	Vol	WBD	FL	FW	LD	DWT
Ht	1							
DBH	.85**	1						
Vol	.97**	.94**	1					
WBD	.12	.00	.11	1				

FL	.05	.01	.03	.16	1			
FW	.42	.36	.43	.00	.07	1		
LD	.48*	.41	.49*	.05	.06	.94**	1	
DWT	.05	.07	.04	.13	.35	.61**	.32	1

*Correlation at 0.05 level and ** at 0.01 level