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EFFECT OF PHYSIO-CHEMICAL PROPERTIES OF SOIL IN THE GROWTH PERFORMANCE OF *Ailanthus excelsa* SELECTIONS IN SOUTHERN INDIA

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ABSTRACT

***Ailanthus excelsa* Roxb. is a deciduous tree species, indigenous to India and belonging to the family Simaroubaceae. This species has an added advantage over the other Multi Purpose Tree Species as it is fast growing and short rotation agro-forestry species. There is a heavy demand of raw material for safety matches industries in Tamil Nadu and it is procured from other states of India. The genetic resources of *A. excelsa* were collected from different agroclimatic zones of India *viz.*, Tamil Nadu, Andhra Pradesh, Rajasthan and Uttarakhand. Field experiments were laid out Randomized Block Design (RBD) with three replications and four trees per replication were adopted spacing of 3x3m in that study period of 2005 to 2010. Two progeny trials have been established in Tirupati (Andhra Pradesh) and Salem (Tamil Nadu) with 55 seed sources of selected CPT's. Soil samples were collected from experimental plots in two different depths such as 0-30cm and 31-60 cm and physio-chemical analysis *viz.,* Soil pH, EC, BD, OC, soil texture and available NPK are done. Growth attributes *viz.,* height, diameter and volume index were recorded in the progeny trail for three consecutive years (2008 to 2010). The data were analyzed using statistical software AGRES and GENRES. In the experimental site, the meteorological data was collected for six consecutive years (2005-2010) has no significant variation observed. But, significant variation was found in the morphological characters. These are evidences for the present study showed that Tirupati trail exhibited better performance in all growth characters with high OC and available NPK comparatively in Salam trail. Besides overall growth performance of *A. excelsa*, it was observed individually(third year) that the progenies of IFGTBAE-45 followed by IFGTBAE-47 of Tirupati trail and IFGTBAE-43 and IFGTBAE-9 in Salam trail were performed better growth in the terms of plant height and basal diameter respectively. Among the growth performance of 55 progeny, Tirupati exhibited 8 sources and 7 sources from Salam trail showed significant difference were found in height, basal diameter and volume index respectively.**

KEYWORDS: *A.excelsa*, BD, CPT, EC, IFGTBAE, NPK, pH and RBD

Ailanthus excelsa Roxb. is a deciduous tree species belonging to the family Simaroubaceae. It is widely distributed in semi-arid and semi moist regions of India. It grows well in areas where the mean annual rainfall ranges from 500 – 1900 mm, sometimes it grows even up to 2500 mm. It has been found to be a suitable species for planting in dry areas of Rajasthan and Tamil Nadu with annual rainfall of about 400 mm. It is indigenous to Central and South India and found throughout Madhya Pradesh, South Bihar, Gujarat, Coastal districts of Andhra Pradesh, parts of Karnataka, Maharashtra, Orissa and Tamil Nadu (Roxburgh, 1832). In Tamil Nadu, it is distributed in districts of Coimbatore, Dharmapuri, Madurai, Kanyakumari, Salem, Erode and Trichirappalli (Nair and Henry, 1983).

A. excelsa is popularly known as the *Tree of Heaven* and it is locally called as *Madala* in Sanskrit, *Maharukh* in Hindi, *Arduso* in Gujarati and *Thee maram* in Tamil. It is a fast growing tree with large pinnate leaves and rough light greyish bark. Flowers are small, greenish in colour and the species is polygamo-dioecious. The fruit is flat, membranous samara and dispersed by wind. The tree possesses mostly straight bole with very few branches and attains utilizable girth in 5-6 years. The wood is light weight, soft and used for making packing cases, match box and sticks, fishing floats and catamarans (Pearson and Brown, 1932). Besides an excellent match wood resource, the species also has several medicinal properties. The bark of the tree is bitter, astringent, that acts as anthelmitic, febrifuge, antispasmodic, antiseptic and as expectorant. It is also used in treating asthma and bronchitis (Parrotta, 2001)

Since, there is a heavy demand of raw material for safety matches industries in Tamil Nadu and it is procured from other states of India. The annual raw material demand for safety matches in India is about 14 lakh tons. *A. excelsa* is currently grown in area of approximately 1000 ha. In Tamil Nadu the safety matches industry predominantly consume this species, as the monthly production goes more than 125 lakh bundles (1 bundle = 600 boxes). In order to produce one bundle of safety matches, 2 kg of splints are required. To meet the monthly production of 125 lakh bundles the splints requirement would be (125×2) 250 lakh kg. About 210 kg of splints may be obtained from one ton of *Ailanthus* wood. Therefore to meet the monthly production of 125 lakh bundles of splints 1,20,000 ton of soft wood is required. For the continuous supply of soft wood for the

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safety match industry with 6 years as rotation period about 1.12 lakh, acres of plantation of *A. excelsa* have to be established. *A. excelsa* being one of the top priority species for the safety match wood industry is thus having a wide scope of cultivation in farm land.

This species has an added advantage over the other Multi Purpose Tree Species (MPTS) as it is fast growing and short rotation agro-forestry species. The architecture of the tree makes it suitable for Agri-silvi production system and indicated higher monetary returns from sole crops in comparison to Agri-silvi production system reported by Tikka *et al.* (2003) and it produces large biomass at very early growth stages. *A. excelsa* is sporadically distributed throughout the state; however it is not popularized as commercial plantation to meet industrial needs. Its fast growth, adaptability to dry areas, ready market and substantial revenue is likely to make this species attractive to farmers. However, no detailed studies have been made for this species to improve the productivity. Tree improvement involves determining genetic variations, selecting individuals with desired characteristics and utilizing it for operational planting programme. It is realized that judicious use of genetic variability availing seed sources from wide collections and silvicultural practices will enhance the yield per unit area.

Agro forestry practices have been shown to influence chemical, physical and biological components of soil fertility (Bayala et al., 2011). Trees can improve nutrient balance of a site both by reducing unproductive nutrient losses from erosion and leaching and by increasing nutrient inputs trough nitrogen fixation; they can improve soil structure, water holding capacity and crop rooting volume; and they can increase the biological activity in the soil by providing biomass and a suitable microclimate(Kalinganire and Bayala, 2010).

The physical, chemical and biological properties are generally less favorable as a rooting medium than soil found on the natural landscape. The soil is formed as a porous medium in profile in form at the earth's atmosphere and lithosphere. It is the result of the interaction of physical disintegration and chemical decomposition of the underlying bedrock or unconsolidated sediments placed there by long term geologic process. The mode of development (genesis) and resultant soil is controlled by the kind of geologic material (parant material) in which the soil forms under given climatic and vegetative conditions, modified by the effect of topography all integrated over time (Brady, 1984). Thus, soil formation is a long term process and due to diversity of the soil forming factors over the landscape, diverse soils are formed in different localities. They will have differences in their physical, chemical and biological properties. These properties determine the capabilities and limitations of a soil for plant growth. So far information's on comparative assessment on effect of different effect of physio-chemical properties of soil in the growth performance of *Ailanthus excelsa* selections are meager in southern Indian condition. Hence, the present investigation was carried out with the following objectives. Survey and selection of superior genetic resources of *Ailanthus excelsa.* Determination of the soil physical and chemical properties in different environmental condition. Assess the growth performance of the selected progenies through field trial evaluation.

MATERIALS AND METHODS

The present investigation was conducted to study the "Effect of physio-chemical properties of soil in the growth performance of A*ilanthus excelsa* selections in southern India". This was carried out in the genetic resources of *Ailanthus excelsa* collected from different agroclimatic zones of Tamil Nadu, Andhra Pradesh, Rajasthan and Uttarakhand. Growth attributes such as basal girth, height, diameter and volume index were recorded in the progeny trails of *A. excelsa* established in Tirupati (Andhra Pradesh) and Salem (Tamil Nadu) for three consecutive years (2008-2010). The details of materials used and various methodologies adopted for the present study are presented in this chapter.

Selection of Superior Genetic Resources of *A. excelsa*

A survey was made in four states of India namely Tamil Nadu, Andhra Pradesh, Rajasthan and Uttarakhand to identify the candidate plus trees of *A. excelsa*. A total number of 55 CPTs were selected sporadic trees based on the morphological features such as basal girth, height, diameter at breast height (DBH), clear bole height and tree volume by following the method of Pitcher and Dorn (1966). The selected CPTs were given with the accession number as IFGTBAE (Institute of Forest Genetics and Tree Breeding *Ailanthus excelsa*). In Tamil Nadu, a total of 49 CPT's (IFGTBAE-1 to IFGTBAE-49) were selected in nine districts namely Theni (13), Coimbatore (12), Salem (7), Dindigul (8), Trichy (6), Perambalur (1), Dharmapuri (1) and Erode (1). In Uttarakhand, each one CPT (totally 4 CPT's) bearing accession number IFGTBAE-51 to IFGTBAE-54 was selected from four districts namely Dehradun, Haridwar, Lachiwala and Doiwala respectively. Jodhpur district of Rajasthan and

Rajamundury district of Andhra Pradesh carries each one CPT with the accession number of IFGTBAE-50 and IFGTBAE-55 respectively.

Establishment of Progeny Trials of *A. excelsa*

Two progeny trials have been established in Tirupati (Andhra Pradesh) and Salem (Tamil Nadu) with 55 seed sources of selected CPT's. The trials were established in Randomized Block Design (RBD) with three replications consisting of four seedlings per replication. The details of two progeny trails are given in Table 1.

Environmental factors

The latitude, longitude of each study locations were recorded using a GPS (Garmin GPSMAP 62s). The rainfall, humidity and temperature data for the two trial locations were collected from the meteorological centers. There was a substantial variation in seasonal rainfall, humidity and slight variation in temperature in both the locations. The mean monthly rainfall, total rainfall and minimum and maximum temperature (Average values of six years) in trial locations were calculated for the period of six years (2005-2010) which includes the investigation period.

Soil samples were collected from both experimental plots at two different depths (0-30 and 31 – 60 cm) the two locations at a depth of 30 cm after scraping the litter. All the soil samples were mixed thoroughly to obtain a uniform representative soil samples. Then these samples were air dried, powdered and allowed to pass through 2 mm sieve, and used for analyzing the various physical properties *viz.* Soil pH(Jackson, 1973), Electrical Conductivity (EC) (Jackson, 1973), Bulk density (Black, 1965), Organic Carbon (Walkley and Black, 1934), Soil texture(Piper, 1966) and The chemical properties of soil such as Available Nitrogen (Subbiah and Asija, 1973), Available Phosphorus (Olsen *et al.*, 1954) and Available Potassium (Stanford and English,1949) were estimated by the following standard procedures. The two progeny trails were evaluated for three consecutive years (2008-2010) and data was recorded for plant height, basal diameter and volume index. The data recorded from field experiments were analyzed using statistical software AGRES and GENRES (7.01version). Estimates of mean, variance and standard error were carried out as per the procedure described by Panse and Sukhatme (1978). The test of significance was carried out by referring to the standard 'F' table of Snedecor (1961).

Table 1: Details of *A. excelsa* progeny trials established in two different locations

Location	Tirupati (Andhra Pradesh)	Salem (Tamil Nadu)
Latitude	13.38° 61'	11.45° 08'
Longitude	79.19° 50'	78.09° 55'
Elevation (m)	154	255
No. of families	80	60
No. of replications	3	3
Trees/family/replication	4	4
Spacing (m)	3 × 3	3 × 3
Total trees	960	720
Year of establishment	2008	2008

RESULTS AND DISCUSSION

Ailanthus excelsa is a deciduous tree, occurs mainly in semi-arid and semi moist regions of India. It is generally absent in heavy rainfall areas of west coast. It grows in the natural habitat where the maximum and minimum temperature varies from 45 to 47.5° C and 0 to 12.5°C respectively. Likewise, the temperature and annual rainfall also varies from 4 to 42.5°C and 500 to 1900 mm respectively and, sometimes this species grow even in the rainfall range of 2500 mm. *A. excelsa* has been recognized as an important tree in social forestry, agroforestry, avenue plantation, industrial plantation and wasteland afforestation. The wood is light and extensively used for making matchwood boxes and match splints. The wood is also used for making wooden toys, packing cases, fishing floats and sword sheaths. The pulp is used in paper industry to improve the surface quality of paper. *A. excelsa* grows well in sloppy areas and stony patches where soil is sandy and porous. The moist and heavy rainfall areas or the area prone to frost is not suitable for this species establishment.

Evaluation of *A. excelsa* Progenies in Experimental Trials

Progeny evaluation is one of the selection methods followed in tree improvement programmes, where superior genotypes are selected based on the performance of their respective progenies at an early age by providing similar environmental (growing) conditions to progenies of selected genotypes (Write, 1976). On the otherhand, progeny testing is one of the research components needed to accomplish long-term genetic gainthrough selection (Eldridge *et al.,* 1993). The two progeny trials of *A. excelsa* established in different

environmental conditions at Tirupati (Andhra Pradesh) and Salem (Tamil Nadu) were evaluated for three consecutive years (2008-2010).

Though meteorological data was collected for six consecutive years (2005-2010), no significant variation was observed in the average (Table 2). The annual average temperature was high in Tirupati (33.56°C) than in Salem (33.88°C). The Salem trial registered with maximum average humidity of 73.23 % with maximum humidity of 82.25 % in the year of 2006, whereas the average humidity was found to be less in Tirupati trial (48.30 %). The average annual rainfall of about 1.84 cm was recorded for Salem trail, of which maximum was recorded in the year of 2005. The results showed significant variations on morphometric characteristics of *A. excelsa*. This variation may be due to environmental conditions which influence growth attributes in several tree species like teak (Krisnamoorthy, 2014; Surendra, 2013), *Pinus radiata* (Solla-Gullon *et al.,* 2008) and *Eucalyptus* (Singh *et al.,* 1990)

The present investigation revealed that, the *A. excelsa* progeny trail established at Tirupati exhibited higher mean increment in three consecutive years for growth attributes such as plant height (0.80 m), basal diameter (7.14-7.45) and volume index (0.03-0.08) in slightly alkaline pH (7.6) whereas these attributes showed comparatively less values in Salem where soil pH was found to be moderate acidic with 5.6 (Table 3, 4 and 5). Kadambi (1972) reported that the growth is less in teak where the pH is below 6.0. Akinsanmi (1985) reported that the soil pH was significantly correlated with teak volume growth. Soil pH was positively correlated with the height and basal area (Ezenwa, 1988). Krishnamoorthy (2014) observed that soil pH in teak plantations in Nilambur and Wayanad (Block-III and IV) showed a positive correlation with tree height and GBH. Similarly, Surendra (2013) reported a positive correlation in soil pH with tree height, DBH and clear bole height in natural teak populations of Karnataka. The present observation revealed that growth attributes in Tirupati trial (Table 11) performed better in high soil EC compared to Salem (Table 3, 4 and 5) indicating that high EC may enhance the growth in *A. excelsa*. It corroborates with the findings of Tanaka *et al.* (1988) that an abundance of exchangeable bases provides optional soil conditions for better growth of teak. Similarly Singh *et al.* (1990) observed a strong positive correlation between tree growth parameters and CEC. Recently, Watanabe *et al.* (2010) reported that an effective cation exchangeable capacity promoted tree height in Ghana.

Chaudhari *et al*. (2012) reported that the bulk density was high in sandy loam soils than in loamy sand soils. Odewumi *et al.* (2013) reported that soil bulk density was less where the available water and water holding capacity of the soil was high which enhances the growth in teak. These are evidences for the present study that Tirupati trail exhibited better performance in all growth characteristics with less bulk density (126.07/100ml gm/cc in 30-60 cm) than Salem trail (Table 2, 4 and 5). The soil texture was found to be sandy loam (in both the trials) (Table 2); which enhance growth in *A. excelsa* at juvenile stage (Table 4 and 5). This is in line with findings of Krishnamoorthy (2014) that the sandy loam soils of four teak plantations in Cauvery canal bank (Block-I) and Cherupuzha of Nilambur (Block-III) showed good growth. Similarly, Surendra (2013) reported that teak exhibited good growth in sandy loam and laterite soils in Karnataka. Soil organic carbon (OC) is a key component of soil-plant ecosystem and it changes with land use or agricultural management practices. The progenies of *A. excelsa* exhibited higher growth mean increment in Tirupati than Salem trial for all the three years studied. This may be due to high OC content in soil enhances the growth in *A. excelsa*. It corroborates the findings of Krishnamoorthy (2014) and Surendra (2013) that teak exhibited enhanced growth in high organic carbon soils.

Macro nutrients such as nitrogen, phosphorus and potassium play a pivotal role among the elements and are very much essential for plant growth. It was proved earlier by several researchers in many tree species. According to Meysner *et al.* (2006), about 93 to 97% of the total nitrogen in the soil is closely associated with organic matters which help to increase plant growth. Ezenwa (1988) observed that the soil nitrogen was positively correlated with tree growth and basal area in 11-year-old young teak plantations in Nigeria. Surendra (2013) reported that Dandeli population showed maximum height and DBH with maximum available phosphorus of 22.82 kg/ha in seven natural teak populations of Karnataka. The soil potassium showed positive correlation with tree height and GBH (Ezenwa, 1988; Krishnamoorthy, 2014). These findings are in line with the present study that high available NPK in Tirupati trail exhibited better growth in terms of height and basal diameter compared to Salem indicating that these nutrients available in soil may enhance the growth attributes in *A. excelsa.*

Besides overall growth performance of *A. excelsa* progenies raised through different seed sources, it was observed individually (third year) that the progenies of

IFGTBAE-45 (Coimbatore-4) and IFGTBAE-47 (Trichy-3) of Tirupati trial performed better growth in terms of plant height (3.82 m) and basal diameter (27.76 cm) respectively (Table 4). Similarly in Salem trail, the progenies of IFGTBAE- 43 (Trichy-1) and IFGTBAE- 9 (Salem-5) exhibited higher values for plant height (3.47 m) and basal diameter (27.58cm) respectively (Table 5). The seed and seedling characteristics of these four progenies were found to be moderate compared to mean. It clearly indicates that environmental factors including soil properties may enhance the growth in *A. excelsa* than genetic factors perhaps the later could be expressed after three years. It is in line with the results of Otegbeye (1990) that no genetic variation among nine provenances of *Eucalyptus tereticornis* was observed up to three years. Similar studies were already been reported in several trees species such as *Gliricidia sepium* (Glover, 1987), *Pterocarpus santalinus* (Rajkumar, 1999), *Azadirachta indica* (Kumaran, (1991) *and Casuarina equisetifolia* (Gunasena and Fernando, 1996). The growth performance of progeniies at Tirupati was better than Salem (Table 4 and 5).the growth data of progeny trial at Tirupati showed that 8 progenies exhibited significant height (3.54 to 3.82 m),basal diameter(25.60 to 27.76 cm) and volume index (0.178 to 0.212 m^3), while at Salem 7 progenies showed a significant height of (3.25 to 3.47 m), basal diameter (25.66 to 26.30 cm) and volume index(0.173 to 0.181m^3) (Table 4 and 5).Similarly Palanisamy *et al*. (2012) reported the variation in plant height and GBH in the field trial of teak of different seed sources.

Table 2: Details of temperature, humidity and rainfall in *A. excelsa* progeny trials at Tirupati and Salem (2006-2010)

S. No	Year	Tirupati trial				Salem trial			
		Temperature (°C)		Humidity (%)	Rainfall (cm)	Temperature (°C)		Humidity (%)	Rainfall (cm)
		Max	Min			Max	Min		
1	2005	34.5	25.33	48.33	0.95	33.26	21.26	72.32	4.85
2	2006	33.47	24.64	51.85	0.93	33.16	22.28	82.25	0.21
3	2007	34.84	26.79	56.63	0.91	34.30	21.24	74.65	0.36
4	2008	33.44	25.25	42.03	1.25	34.45	21.60	73.27	1.92
5	2009	33.15	25.31	41.47	1.98	35.22	22.24	70.39	0.14
6	2010	31.96	26.02	49.49	1.09	32.90	20.45	72.49	3.53
Average		**33.56**	**25.56**	**48.30**	**1.19**	**33.88**	**21.51**	**74.23**	**1.84**

Table 3: Soil parameters of *A. excelsa* progeny trials at Tirupati and Salem

Location	Depth (in cm)	pH	EC (dS/m)	Bulk Density (gm/cc)	OC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (ppm)	Texture
Tirupati	0-30	5.4	0.55	135.64/100ml	0.77	117.00	24.26	163.1	Sandy loam
	30-60	6.0	0.53	126.07/100ml	0.49	144.06	24.83	209.7	
Average		**5.7**	**0.54**	**130.86/100ml**	**0.65**	**130.53**	**24.55**	**186.4**	
Salem	0-30	7.6	0.16	130.51/100ml	0. 20	119.00	23.36	210.0	Loam
	30-60	7.6	0.13	130.34/100ml	0.12	121.41	22.55	112.3	
Average		**7.6**	**0.15**	**130.43/100ml**	**0.12**	**120.21**	**22.96**	**161.2**	

EC – Electrical conductivity, OC- Organic Carbon, N- Available Nitrogen, P- Available Phosphorus, K-Available potassium.

Table 4: Growth characteristics of *A. excelsa* progenies in Tirupati (Andhra Pradesh)

CPT's No.	Location	Height (m)			Basal diameter (cm)			Volume index (m^3)		
		Years			Years			Years		
		I	II	III	I	II	III	I	II	III
IFGTBAE- 1	Coimbatore-1	1.59	2.57*	3.64**	9.43**	16.50**	25.60**	0.011*	0.055**	0.186**
IFGTBAE- 2	Coimbatore-2	1.58	2.47	3.60**	9.50**	16.86**	25.85**	0.011*	0.055**	0.190**
IFGTBAE- 3	Coimbatore-3	1.02	1.59	1.94	7.82	13.64	22.24	0.005	0.023	0.069
IFGTBAE- 4	Erode – 1	1.16	1.77	2.20	8.24	14.78	20.61	0.006	0.031	0.072
IFGTBAE- 5	Salem – 1	1.23	1.80	2.13	8.40	13.69	17.00	0.007	0.027	0.047
IFGTBAE- 6	Salem – 2	1.63	2.45	3.62**	9.21**	18.58**	26.71**	0.011*	0.066**	0.200**
IFGTBAE- 7	Salem – 3	1.20	1.71	2.32	8.56	15.74	23.75*	0.007	0.033	0.100
IFGTBAE- 8	Salem – 4	1.30	2.03	2.80	5.64	12.94	17.87	0.003	0.027	0.069
IFGTBAE- 9	Salem – 5	1.29	1.83	2.71	7.76	14.59	18.07	0.006	0.030	0.069
IFGTBAE- 10	Salem – 6	1.31	2.35	3.20	8.39	15.27	23.45	0.007	0.043	0.138
IFGTBAE- 11	Salem – 7	1.47	2.47	3.46*	9.20**	16.83**	26.50**	0.010	0.055**	0.190**
IFGTBAE- 12	Dharmapuri	1.48	2.49	3.56**	9.02	16.98**	25.67**	0.009	0.056**	0.178**
IFGTBAE- 13	Pollachi -1	1.24	1.49	2.56	6.51	13.36	20.08	0.004	0.021	0.080
IFGTBAE- 14	Pollachi -2	1.33	2.30	3.32	8.80	16.50**	24.83**	0.008	0.049	0.166**
IFGTBAE- 15	Pollachi -3	1.14	1.39	2.24	5.73	11.68	22.58	0.003	0.015	0.090
IFGTBAE- 16	Pollachi -4	1.48	2.48	3.41*	9.21**	17.00**	26.34**	0.010	0.056**	0.188**
IFGTBAE- 17	Pollachi -5	1.23	2.38	3.20	8.28	15.63	24.00*	0.007	0.046	0.153**
IFGTBAE- 18	Pollachi -6	0.90	1.53	2.51	6.70	12.92	17.31	0.003	0.020	0.055
IFGTBAE- 19	Pollachi -7	1.24	1.43	2.58	7.29	14.33	20.58	0.005	0.023	0.088
IFGTBAE- 20	Pollachi -8	1.16	1.60	2.65	5.69	13.52	18.00	0.003	0.023	0.069
IFGTBAE- 21	Palani -1	1.45	2.50*	3.54*	9.10**	16.25*	26.66**	0.009	0.052**	0.200**
IFGTBAE- 22	Palani -2	1.30	2.25	3.27	8.60	16.03	22.08	0.008	0.045	0.123
IFGTBAE- 23	Palani -3	1.39	2.19	2.52	7.29	14.36	17.98	0.006	0.035	0.063
IFGTBAE- 24	Palani -4	1.37	1.84	2.61	8.24	14.83	17.64	0.007	0.032	0.067

IFGTBAE- 25	Palani -5	1.12	1.58	2.31	6.22	13.39	20.60	0.003	0.022	0.078
IFGTBAE- 26	Virupachi	1.47	2.50*	3.57**	9.13**	16.23*	27.01**	0.010	0.052**	0.206**
IFGTBAE- 27	Dindigul -1	1.29	1.69	2.41	8.16	14.64	18.33	0.007	0.029	0.065
IFGTBAE- 28	Dindigul -2	0.98	1.49	2.58	7.86	13.08	17.00	0.005	0.020	0.057
IFGTBAE- 29	Theni- 1	1.54	2.03	2.46	8.23	13.51	22.25	0.008	0.029	0.095
IFGTBAE- 30	Theni -2	1.53	2.24	2.74	7.44	14.73	24.61**	0.007	0.038	0.132
IFGTBAE- 31	Theni -3	0.99	1.68	2.59	6.48	13.59	22.01	0.003	0.024	0.094
IFGTBAE- 32	Theni -4	1.37	2.24	2.61	7.55	14.39	22.48	0.006	0.037	0.106
IFGTBAE- 33	Theni -5	1.20	2.31	3.21	7.54	15.55	22.97	0.005	0.044	0.127
IFGTBAE- 34	Theni -6	1.40	1.74	2.60	6.25	14.67	18.66	0.004	0.029	0.072
IFGTBAE- 35	Theni -7	1.49	2.48	3.49**	9.34**	16.50**	26.25**	0.010	0.053**	0.194**
IFGTBAE- 36	Theni -8	1.07	1.44	2.13	6.48	14.53	17.40	0.004	0.024	0.051
IFGTBAE- 37	Theni -9	1.49	2.32	2.66	8.62	14.56	17.83	0.009	0.039	0.064
IFGTBAE- 38	Theni -10	0.74	1.33	1.59	5.31	13.14	17.29	0.002	0.018	0.038
IFGTBAE- 39	Theni -11	0.56	1.84	2.38	5.19	12.61	17.50	0.001	0.023	0.061
IFGTBAE- 40	Theni -12	1.30	2.29	2.63	7.87	14.83	18.69	0.006	0.040	0.072
IFGTBAE- 41	Theni -13	1.16	2.32	2.99	7.04	14.59	19.45	0.004	0.039	0.088
IFGTBAE- 42	Perambalur	1.03	2.16	2.86	6.92	15.21	19.00	0.004	0.039	0.077
IFGTBAE- 43	Trichy -1	1.58	2.80**	3.63**	8.95*	16.81**	27.36**	0.010	0.062**	0.212**
IFGTBAE- 44	Musiri	1.32	2.28	2.64	8.25	14.17	21.99	0.007	0.036	0.097
IFGTBAE- 45	Coimbatore-4	1.64*	2.86**	3.82**	9.61**	16.60**	26.83**	0.012*	0.062**	0.220**
IFGTBAE- 46	Trichy -2	1.56	2.46	3.40*	8.89*	16.50**	27.45**	0.010	0.052**	0.203**
IFGTBAE- 47	Trichy -3	1.78**	2.67**	3.47*	9.08**	16.39**	27.76**	0.012*	0.056**	0.212**
IFGTBAE- 48	Trichy -4	1.37	2.32	3.17*	7.96	15.63	24.12**	0.007	0.044	0.150*
IFGTBAE- 49	Trichy -5	1.48	2.53*	3.54**	9.08**	16.46**	27.50**	0.010	0.054**	0.209**
IFGTBAE- 50	Rajasthan	1.67*	2.43	3.51*	9.50**	16.94**	26.67**	0.012*	0.055**	0.189**
IFGTBAE- 51	Uttarakhand – 1	1.54	2.44	3.42*	9.11**	16.56**	26.96**	0.010	0.052**	0.196**
IFGTBAE- 52	Uttarakhand – 2	1.52	2.41	3.48*	9.28**	16.45**	27.44**	0.010	0.051*	0.208**

IFGTBAE- 53	Uttarakhand – 3	1.51	2.49	3.40*	9.12**	16.41**	26.83**	0.010	0.053**	0.191**
IFGTBAE- 54	Uttarakhand – 4	1.56	2.46	3.50*	9.38**	16.53**	27.08**	0.011	0.053**	0.204**
IFGTBAE- 55	Andhra Pradesh	1.50	2.55*	3.48*	9.81**	16.81**	26.03**	0.011	0.057**	0.186**
Mean		**1.33**	**2.13**	**2.94**	**8.04**	**15.18**	**22.63**	**0.007**	**0.040**	**0.127**
SEd		**0.15**	**0.19**	**0.22**	**0.39**	**0.44**	**0.54**	**0.021**	**0.005**	**0.010**
CD(0.05)		**0.31**	**0.37**	**0.43**	**0.78**	**0.87**	**1.07**	**0.004**	**0.010**	**0.019**
CD(0.01)		**0.40**	**0.48**	**0.57**	**1.03**	**1.15**	**1.42**	**0.006**	**0.012**	**0.026**

** significant at 0.01 level (2-tailed), * significant at 0.05 level (2-tailed)

Table 5: Growth characteristics of *A. excelsa* progenies in Salem (Tamil Nadu)

CPT's No.	Location	Height (m)			Basal diameter (cm)			Volume index (m^3)		
		Years			Years			Years		
		I	II	III	I	II	III	I	II	III
IFGTBAE- 1	Coimbatore-1	1.26	2.27*	3.25**	10.76	18.08	26.30*	0.011	0.058**	0.177**
IFGTBAE- 2	Coimbatore-2	1.39	2.73**	3.16*	11.51	18.10	25.19	0.014*	0.070**	0.158**
IFGTBAE- 3	Coimbatore-3	0.86	1.45	1.60	8.58	11.06	16.25	0.005	0.014	0.033
IFGTBAE- 4	Erode – 1	1.05	1.68	2.19	10.33	13.86	20.47	0.009	0.025	0.073
IFGTBAE- 5	Salem – 1	1.07	1.38	2.37	10.18	15.00	22.28	0.009	0.025	0.095
IFGTBAE- 6	Salem – 2	1.32	2.32*	3.34**	12.38**	18.34	25.66*	0.016**	0.061**	0.173**
IFGTBAE- 7	Salem – 3	0.58	1.19	1.72	6.83	13.35	20.75	0.002	0.017	0.057
IFGTBAE- 8	Salem – 4	0.89	2.38**	2.74	10.04	15.42	23.27	0.008	0.045	0.117
IFGTBAE- 9	Salem – 5	1.04	2.31*	2.72	9.84	16.76	27.58**	0.008	0.051	0.164**
IFGTBAE- 10	Salem – 6	0.98	1.63	2.01	10.57	15.67	21.98	0.009	0.031	0.077
IFGTBAE- 11	Salem – 7	1.31	2.38**	3.05*	11.21	17.25	25.20	0.013	0.056*	0.155**
IFGTBAE- 12	Dharmapuri	1.35	2.52	3.30**	12.13*	17.89	25.39	0.015**	0.063**	0.167**
IFGTBAE- 13	Pollachi -1	0.61	1.43	1.68	10.09	15.67	21.67	0.005	0.027	0.062
IFGTBAE- 14	Pollachi -2	1.18	2.45**	3.29**	11.03	18.00	25.97*	0.011	0.062**	0.174**
IFGTBAE- 15	Pollachi -3	1.09	1.50	1.75	7.46	15.83	23.41	0.005	0.030	0.075

IFGTBAE- 16	Pollachi -4	1.34	2.26*	3.42**	10.95	17.33	25.78*	0.013	0.053*	0.178**
IFGTBAE- 17	Pollachi -5	0.88	1.16	1.71	8.10	13.75	18.71	0.005	0.017	0.047
IFGTBAE- 18	Pollachi -6	1.08	1.42	2.11	9.04	12.73	18.14	0.007	0.019	0.056
IFGTBAE- 19	Pollachi -7	1.07	1.48	2.03	10.25	16.17	22.01	0.009	0.031	0.077
IFGTBAE- 20	Pollachi -8	1.08	1.99	2.40	9.14	12.92	20.82	0.007	0.026	0.082
IFGTBAE- 21	Palani -1	1.23	2.37**	3.26**	11.33	17.97	26.26*	0.012	0.060**	0.177**
IFGTBAE- 22	Palani -2	0.75	1.37	1.96	7.79	15.43	23.72	0.004	0.026	0.087
IFGTBAE- 23	Palani -3	0.88	1.34	2.01	8.83	14.78	21.42	0.005	0.023	0.073
IFGTBAE- 24	Palani -4	1.01	1.65	2.27	10.14	15.75	22.21	0.009	0.032	0.088
IFGTBAE- 25	Palani -5	1.07	1.70	2.12	9.75	13.72	19.33	0.008	0.025	0.063
IFGTBAE- 26	Virupachi	1.23	2.39**	3.43**	11.33	18.08	26.00*	0.012	0.061**	0.181**
IFGTBAE- 27	Dindigul -1	0.90	1.52	1.96	8.50	13.92	19.03	0.006	0.023	0.056
IFGTBAE- 28	Dindigul -2	0.75	2.10	2.70	10.08	15.08	19.71	0.005	0.038	0.083
IFGTBAE- 29	Theni- 1	0.91	1.72	2.13	8.92	14.11	21.74	0.006	0.028	0.079
IFGTBAE- 30	Theni -2	1.09	1.92	2.54	10.10	14.83	23.32	0.009	0.035	0.111
IFGTBAE- 31	Theni -3	1.10	1.65	2.04	9.33	14.75	20.69	0.007	0.029	0.071
IFGTBAE- 32	Theni -4	1.14	1.48	1.94	10.03	14.00	20.91	0.009	0.024	0.066
IFGTBAE- 33	Theni -5	0.63	1.42	2.26	9.23	14.67	20.42	0.005	0.024	0.073
IFGTBAE- 34	Theni -6	1.09	1.63	2.03	9.79	14.56	19.69	0.008	0.030	0.065
IFGTBAE- 35	Theni -7	1.26	2.22	3.29**	10.63	17.83	25.72*	0.011	0.056*	0.172**
IFGTBAE- 36	Theni -8	1.04	1.49	1.99	9.78	15.17	24.17	0.008	0.029	0.094
IFGTBAE- 37	Theni -9	1.00	1.35	1.68	10.08	13.22	21.17	0.008	0.018	0.059
IFGTBAE- 38	Theni -10	1.06	1.56	2.02	9.07	13.65	19.50	0.007	0.023	0.060
IFGTBAE- 39	Theni -11	1.01	1.33	1.73	10.12	14.40	20.17	0.009	0.022	0.055
IFGTBAE- 40	Theni -12	0.71	1.18	1.88	8.07	14.31	19.91	0.004	0.019	0.060
IFGTBAE- 41	Theni -13	1.13	1.50	1.83	9.13	15.15	21.22	0.007	0.028	0.068
IFGTBAE- 42	Perambalur	1.02	1.69	1.99	9.48	16.68	24.94	0.007	0.038	0.102
IFGTBAE- 43	Trichy -1	1.23	2.29*	3.47**	11.29	17.71	25.75*	0.012	0.056*	0.180**

IFGTBAE- 44	Musiri	0.88	1.34	1.52	9.34	12.94	18.44	0.006	0.017	0.041
IFGTBAE- 45	Coimbatore-4	1.24	2.24*	3.45**	10.99	18.45*	25.42	0.012	0.060**	0.175**
IFGTBAE- 46	Trichy -2	1.29	2.14	3.29**	12.18*	17.86	25.00	0.015**	0.053*	0.162**
IFGTBAE- 47	Trichy -3	1.22	2.11	3.26**	10.33	19.08*	25.17	0.010	0.061**	0.162**
IFGTBAE- 48	Trichy -4	1.04	1.61	2.23	8.63	15.44	22.33	0.006	0.030	0.089
IFGTBAE- 49	Trichy -5	1.25	2.00	3.08*	10.45	18.83*	25.75*	0.011	0.055*	0.159**
IFGTBAE- 50	Rajasthan	1.35	2.15	3.13*	11.14	18.78*	25.81*	0.013	0.059**	0.165**
IFGTBAE- 51	Uttarakhand - 1	1.18	2.16	3.06*	10.67	18.09	25.61*	0.010	0.055*	0.157**
IFGTBAE- 52	Uttarakhand - 2	1.22	2.16	3.19**	10.33	19.03*	25.28	0.010	0.062**	0.161**
IFGTBAE- 53	Uttarakhand - 3	1.26	2.06	3.13*	11.46	18.22	24.34	0.013	0.054*	0.145*
IFGTBAE- 54	Uttarakhand - 4	1.19	2.19	3.20**	10.25	19.42**	25.61*	0.010	0.066**	0.166**
IFGTBAE- 55	Andhra Pradesh	1.23	2.16	3.12*	10.72	18.09	25.75*	0.011	0.056*	0.162**
Mean		**1.07**	**1.84**	**2.51**	**10.00**	**15.95**	**22.88**	**0.009**	**0.039**	**0.110**
SEd		**0.18**	**0.20**	**0.25**	**0.88**	**1.22**	**1.32**	**0.002**	**0.007**	**0.017**
CD(p=0.05)		**0.36**	**0.39**	**0.50**	**1.75**	**2.42**	**2.61**	**0.005**	**0.014**	**0.034**
CD(p=0.01)		**0.48**	**0.52**	**0.66**	**2.32**	**3.20**	**3.45**	**0.006**	**0.019**	**0.045**

** significant at 0.01 level (2-tailed), * significant at 0.05 level (2-tailed)

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