International Journal of Plant & Soil Science

Volume 37, Issue 10, Page 52-57, 2025; Article no.IJPSS.144495
ISSN: 2320-7035

Growth Performance of Different Tree Species Grown under Industrial Agroforestry System in South Gujarat, India

D J Jilariya [a++*], V M Prajapati [a#], B N Bhanderi [a++] and M B Tandel [a†]

[a] College of Forestry, Navsari Agricultural University, Navsari, 396450, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2025/v37i105761

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/144495

Short Research Article

Received: 20/07/2025
Published: 29/09/2025

ABSTRACT

Fast growing tree species with multipurpose benefits such as plywood, pulpwood, timber and fuel wood are suitable for undertaking plantation or agroforestry model with focus to provide wood for industrial needs. Thus, in the recent scenario the fast-growing species has attracted greater attraction by farmers, foresters and plantation growers. Hence, the plantations of fast growing, short rotation woody trees like *Casuarina equisetifolia, Melia dubia, Eucalyptus globulus, Leucaena leucocephala* is gaining more importance across the south Gujarat region. The fundamental hypothesis of the present experiment was to estimate growth parameters like, Height, Girth and Crown spread of species after five years to find out performance of these four tree species.

[++]SRF;
[#]Associate Professor;
[†]Principal & Dean;
**Corresponding author: E-mail: djjilariya@gmail.com;*

Cite as: *D J Jilariya, V M Prajapati, B N Bhanderi, and M B Tandel. 2025. "Growth Performance of Different Tree Species Grown under Industrial Agroforestry System in South Gujarat, India". International Journal of Plant & Soil Science 37 (10):52–57. https://www.journalijpss.com/index.php/IJPSS/article/view/5761.*

Maximum tree height found in *Eucalyptus globulus* (13.84 m), maximum tree girth found in *Leucaena leucocephala* (44.22 cm), maximum tree Crown spread (E-W) found in *Eucalyptus globulus* and *Leucaena leucocephala* (1.97 m*)* while maximum tree Crown spread (N-S) found in *Eucalyptus globulus* (1.96 m).

Keywords: Agroforestry; crown spread; growth parameters; industrial.

1. INTRODUCTION

The association and combination of trees with human kind has been well noted and documented in the ancient civilization and literature available in public domain. In recent times with the advent of development the same humankind has diverted ways from trees and hence, is facing problems like climate change, erratic climatic events and catastrophes, pollution, fire, cyclones *etc*. A remedy for this lies in planting trees as supported by the findings of UNDP, (2023); Thambi, (2024); Buis, (2019). For a layman agro-forestry means growing of trees along with agricultural crops in any combination. Also, agro-forestry serves as ideal technique to combat pressures on forests in general and trees in particular and is safeguard to the ill effects of climate change (Quandt *et al.,* 2023). This has also been pressurized in National Agroforestry Policy, 2014 wherein Agroforestry is been defined as the combination of land use system combining trees and shrubs on farmlands and rural landscapes in combination or with/without animals in order to increase the productivity, profitability, diversity and ecosystem sustainability (Singh *et al.*, 2021).

Agroforestry finds its place in the roots of our country and was practiced traditionally in India in the form of subsistence farming, but in recent times it is being increasingly recognized from the economic point of view, markedly in the wood based industrial sector in present scenarios (Government of India, Ministry of Agriculture and Cooperation, 2014). Indian forests are amongst lowest in productivity worldwide also the legislations present are in favour of only protection and conservation of forests hence, resulting in higher demand for wood and associated products but lower production. To this the National Forest Policy 1988 also dictates that all wood-based industries to generate their own raw material resources by linking farmers and extending technology and market support (Parthiban *et al*. 2021). The state of Gujarat has a wide stretch under the arid and semi-arid ecologies where the tree species mainly dominating the landscapes are *Leucaena spp.*, *Prosopis spp.*, *Acacia spp.*, and *Ficus spp.* also silvi-agriculture and silvo-pastoral agroforestry system involving exotics *viz.*, *Eucalyptus spp.*, *Leucaena spp., Casuarina spp.* and similar fast-growing species (Government of India, Ministry of Environment and Forests, 1988).

To address this mismatched demand and supply of wood for industrial needs agroforestry can play important and major role. Industrial agroforestry involves practicing agroforestry to fulfil the demands of industry hence, involves growing fast growing tree species. Keeping this in mind four different tree species likely, *Casuarina equisetifolia, Melia dubia, Eucalyptus globulus, Leucaena leucocephala* were established under different four models to study their growth pattern when utilized in silvi-agriculture based agroforestry system.

2. MATERIALS AND METHODS

2.1 Study Area

The growth of trees were studied during 2023-24 at instructional farm, arboretum, College of Forestry, Navsari Agricultural University, Navsari, South Gujarat. The study location is located at 20.95° N latitude and 72.93° E longitude with an elevation of 11 m above mean sea level (AMSL). The climate is characterized as humid and warm monsoon with rainfall of about 1500-1800 mm with moderately cold winter and fairly hot and humid summer.

2.2 Methodology

Five-year-old plantations of *Casuarina equisetifolia, Melia dubia, Eucalyptus globulus, Leucaena leucocephala* were established under different four models at spacing of 3×2 m with a total of 32 trees for each species. The trees were planted in the four blocks (128 trees) (Fig. 1). This experiment was designed in a randomised block design with four treatments (different tree species) viz., T_1: -*Casuarina equisetifolia*, T_2: -*Melia dubia*, T_3: -*Eucalyptus globulus*, T_4: -*Leucaena leucocephala* having four replications. To find out the better growth performance of tree species growth parameters *viz.*, Tree height (m),

Chart 1. Volumetric equations used for different tree species in south Gujarat

Sl. No.	Tree species	Equation Used	Reference
1.	*Eucalyptus*	$V= 0.000004 \times D^{2.143} \times H^{1.509}$	Tewari and Singh (2006)
2.	*Melia dubia*	$V= 0.003 + 0.00003 \times HD^2$	Thakur *et al.,* (2021)
3.	*Casuarina equisetifolia*	$V= 0.00005 \times HD^2 + 0.0196$	Gunaga *et al.,* (2023)

Here, V= Volume; D = Diameter at breast height and H = Height of tree

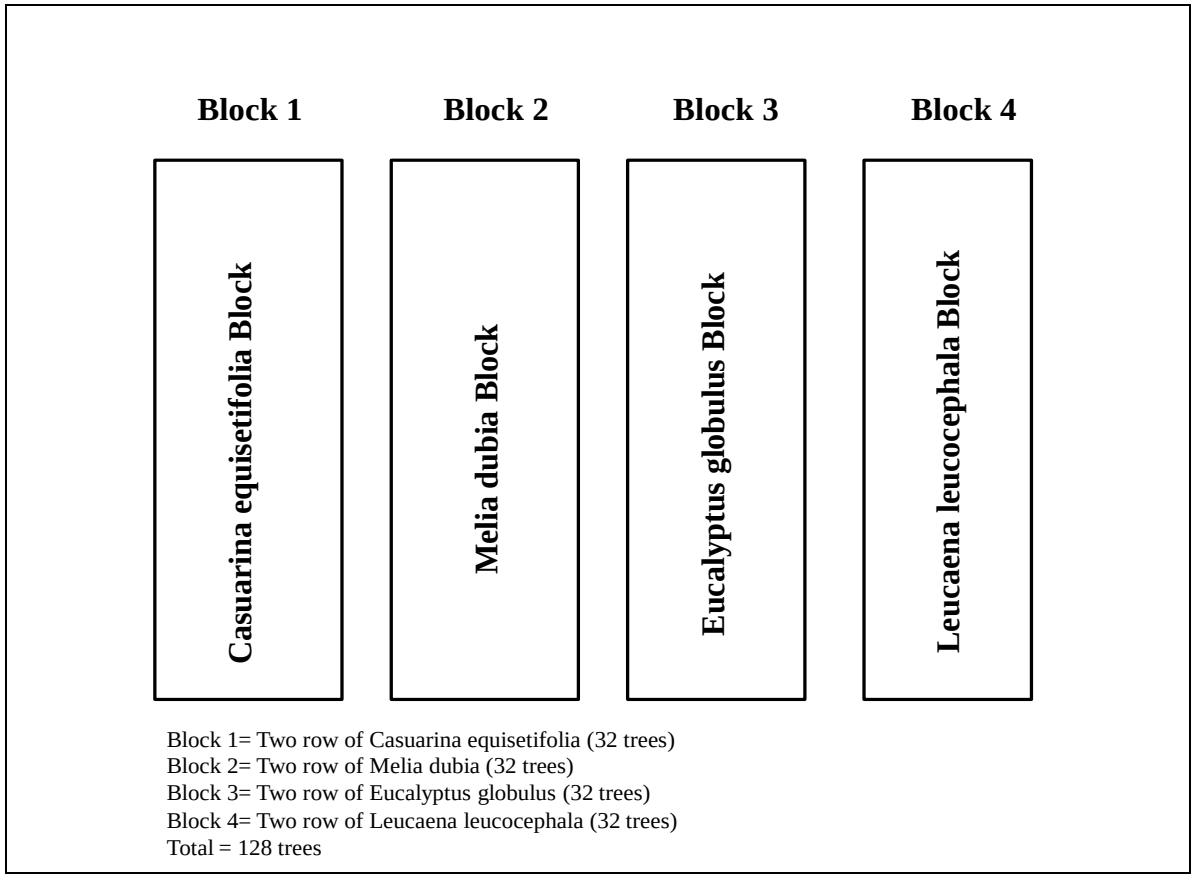

Fig. 1. Layout of different tree species at experimental site, Navsari campus

Tree girth (cm), Tree crown spread (E-W) and Tree crown spread (N-S) were measured. Tree height was measured by US Criterion dendrometer, Tree girth at breast height (1.37 m) and crown spread was measured using a measuring tape for each and every individual tree. Based on the growth performance local volume equation derived for South Gujarat conditions were also used to get an approximate estimate of the volume accumulated by tree species in the agroforestry models (Chart 1).

2.3 Statistical Analysis

Recorded average data of growth parameters were analysed and compared by analysis of variance (ANOVA) of randomised block design with the critical difference, C.V. and S.E.M. (Panse and Sukhatme 1995).

3. RESULTS AND DISCUSSION

3.1 Tree Height (m) and Tree Girth (Girth at Breast Height (cm)

There was a significant variation in height and girth among studied tree species after 5 years till the observations were recorded (Table 1). *Eucalyptus globulus* attained maximum height (13.84 m) and *Leucaena leucocephala* shows minimum height (8.90 m). While, *Leucaena leucocephala* attained maximum girth (44.22 cm) and *Casuarina equisetifolia* shows minimum girth (30.35 cm) at the end of 5 years period of growth when raised in agroforestry model. However, results indicate that among established four tree species *Eucalyptus* gained good height as compared to other and maximum girth was gained by *Leucaena leucocephala* in our case.

Thakur *et al.* (2023) provided support for this finding, revealing significant variation in tree height and DBH growth, GJ09 (local family from Northern most tip of Western Ghats, parts falling in Gujarat) achieved significantly maximum height (11.20 and 13.33 m, respectively) and DBH (15.26 and 18.00 cm, respectively) compared other families. Patil *et al*. (2017) provided support for this finding, revealing significant difference among different planting densities and maximum was recorded in planting density of 714 trees/ha (46.85 cm, 10.59 m; 50.14 cm, 10.99 m; 52.99 cm,11.22 m and 55.76 cm,11.43 m) for both girth (cm) and height (m), respectively for all the time interval. Tree height (*Acrocarpus fraxinifolius*) varied significantly and the maximum tree height was recorded in Mudigere and Chikamagaluru (26.14 m) populations. The difference in GBH was found to be non-significant across the populations, which could be due to selection of trees in particular girth class, as described by (Ashwath *et al.* 2020). As per Dechamma *et al.* (2020) among the different clones of *Casuarina*, Clone CH-10 showed substantially higher growth in terms of DBH (2.96 cm). However, tree height was found to be maximum in CH-2 (4.01 m) which was at par with CH-10, CH-4 and CH-5. Further, consistent lower performance of the intraspecific hybrid (CJ-9) observed for the parameters such as height (3.39 m), DBH (2.23 cm), and volume (443.27 cm3). In Sindigere among all the clones, CH-4 showed better growth performance in terms of quantitative traits such as total height (4.64m), DBH (3.04 cm), CBH (0.81 m) and volume (1159.22 cm3). Similar, result was observed by (Dejenea *et al.* 2018) that Eucalyptus species showed good growing performances both in height and in DBH.

3.2 Tree Crown Spread (E-W) and Crown Spread (N-S)

There was a significant variation in crown spread (E-W) and crown spread (N-S) among studied tree species (Table 1). *Eucalyptus globulus and Leucaena leucocephala* both attained maximum crown spread (E-W) (1.97 m) and *Melia dubia* shows minimum crown spread (E-W) (1.38 m). *Eucalyptus globules* attained maximum crown spread (N-S) (1.96 m) which was statistically at par with *Leucaena leucocephala* (1.93 m) and *Melia dubia* showed minimum crown spread (N-S) (1.36 m), respectively. Similar result were reported by (Shambharkar *et al.* 2024) examining CS-NS aspect variation between *Pterocarpus marsupium* and *Pterocarpus santalinus*, irrespective of their seed sources and locations. Specifically, *P. marsupium* exhibited a wider CS-NS aspect (14.01 m), contrasting with the narrower CS-NS aspect (9.79 m) observed in *P. santalinus*, which ranges from 7.80 m to 22.65 m and higher range 5.30 m to 24.00 m, respectively. Das *et al.* (2019) observed the maximum canopy spread was recorded in *Albizia procera* and *M. azedarach*. The minimum canopy spread was recorded in *Pongamia pinnata* followed by *Aegle marmelos*, and *Azadirachta indica* which suggested the suitability of these species to be planted at a closer spacing under different agroforestry systems. It is worth noting that both species have spreading branches, as described by Gopikumar *et al.* (2003) where *Pterocarpus marsupium* had a highly spreading crown, while *Pterocarpus santalinus* was described as having stout, crooked stems with ranged widely spreading branches.

3.3 Estimated Volume Acquired by the Tree Species in South Gujarat Conditions

An approximate estimate was made by following the already established volumetric equations available in literature (Table 2). It was revealed that *Casuarina equisetifolia* accumulated higher volume (123.93 m^3/ha) followed by *Melia dubia* (75.73 m^3/ha) and *Eucalyptus spp.* (56.33 m^3/ha) towards the end of 5 years period of growth. The findings of the volume can be justified

Table 1. Growth performance of different tree species

Treatments	Height (m)	Girth (cm)	Crown spread (m) (E-W)	Crown spread (m) (N-S)
Casuarina equisetifolia L.	11.72	30.35	1.71	1.69
Melia dubia Cav.	10.63	36.22	1.38	1.36
Eucalyptus globulus Labill.	13.84	33.54	1.97	1.96
Leucaena leucocephala (Lam.) de Wit.	8.90	44.22	1.97	1.93
C.D. at 5%	1.08	3.26	0.09	0.11
SE(m)	0.33	1.00	0.03	0.03
C.V. %	5.91	5.57	3.01	3.93

Table 2. Predicted approximate accumulated volume by different trees species

Sl. No.	Tree Species	Height (m)	DBH (cm)	Volume (m^3/tree)	Volume of trees standing in model (m^3)	Volume (m^3/ha)	Volume (ton/ha)
1.	*Eucalyptus*	13.84	10.68	0.033	1.081	56.334	49.57
2.	*Melia*	10.63	11.53	0.045	1.453	75.734	66.64
3.	*Casuarina*	11.72	9.66	0.074	2.379	123.93	109.06

for *Casuarina* as per Gunaga *et al.* (2023) where the volume of tree having similar DBH and height varies from 0.094 to 0.165 m^3, similarly Thakur *et al.* (2023) found that *Melia dubia* at the end of 5 years gave maximum volume accumulation of 0.081 m^3 and that of *Eucalyptus* in south Gujarat conditions was recorded to be in the range of 0.12 to 0.28 m^3 by Behera *et al*. (2016). Though the findings are not in the required ranges as per the quoted references however, the values are comparable to these.

4. CONCLUSION

Based on the above findings, it can be concluded that the experiment demonstrated the variation in tree height, tree girth and crown spread (E-W) and (N-S) among four different tree species. Among all the tree species *Eucalyptus globulus* attained maximum height that implies that the growth rate of *Eucalyptus globulus* was higher than other tree species while, *Leucaena leucocephala* attained maximum girth depicting higher peripheral growth gained by it. In terms of canopy expansion *Eucalyptus globules and Leucaena leucocephala* attained maximum crown spread (E-W) as compare to other studied tree species. Further, maximum volume was acquired by *Casuarina equisetifolia* amongst all the tree species studied.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

ACKNOWLEDGEMENT

The experiment was funded by the Government of Gujarat, India, through the Development of Industrial Agroforestry Models for South Gujarat Region plan project. We sincerely thank Navsari Agricultural University, Gujarat, India, for granting us access to the facilities needed to complete this experiment.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Ashwath, M. N., Satish, B. N., Devagiri, G. M., Hegde, R. K., & Hareesh, T. S. (2020). Variation in growth traits of *Acrocarpus fraxinifolius* Wight and Arn populations in Southern Karnataka, India. *International Journal of Current Microbiology and Applied Sciences, 9*(8), 1838–1843.

Behera, L. K., Patel, D. P., Gunaga, R. P., Mehta, A. A., & Jadeja, D. B. (2016). Clonal evaluation for early growth performance of *Eucalyptus* in south Gujarat, India. *Journal of Applied and Natural Science, 8*(4), 2066–2069.

Buis, A. (2019). Examining the viability of planting trees to help mitigate climate change. *Explore, NASA Science Editorial Team.* https://science.nasa.gov (cited on 19.09.25).

Das, B., Sarkar, P. K., Kumari, N., Dey, P., Singh, A. K., & Bhatt, B. P. (2019). Biophysical performance of different multipurpose tree species in Jharkhand, India. *Current Science, 116*(1), 82–88.

Dechamma Deepthi, N. L., Hegde, R., Maheswarappa, V., Ganapathi, Varghese, M., Ravi, N., & Nicodemus, A. (2020). Assessment of growth traits of *Casuarina* clones at diverse sites in Karnataka. *International Journal of Current Microbiology and Applied Sciences, 9*(11), 1348–1356.

Dejenea, T., Kidaneb, B., Bahirua, T., Semerea, M., Sisaya, K., & Tadessea, E. (2018). Comparative growth performance of fast-growing tree species for woodfuel production in highland area of Ethiopia. *Horticulture International Journal, 2*(6), 309–316.

Gopikumar, K., Gopakumar, S., & Anoop, E. V. (2003). *Forest nursery and tree husbandry*. International Book Distributors, Dehradun. 170p.

Government of India, Ministry of Agriculture and Cooperation. (2014). *National Agroforestry Policy*. New Delhi, India, pp. 1–25.

Government of India, Ministry of Environment and Forests. (1988). *National Forest Policy*. New Delhi, India, pp. 1–56.

Gunaga, R. P., Behera, L. K., Sinha, S. K., Mehta, A. A., Thakur, N. S., Garde, Y. A., Bhusara, J. B., & Sondarva, R. L. (2023). *Indian Journal of Ecology, 50*(5), 1368–1372.

Panse, V. G., & Sukhatme, P. V. (1985). *Statistical methods for agricultural workers* (4th enlarged ed., revised by Sukhatme, P. V. & Amble, V. N.). Sat Prakash, Under-Secretary for ICAR, New Delhi, India.

Parthiban, K. T., Fernandaz, C. C., Sudhagar, R. J., Sekar, I., Kanna, S. U., Rajendran, P., Devanand, P. S., Vennila, S., & Kumar, N. K. (2021). Industrial agroforestry—A sustainable value chain innovation through a consortium approach. *Sustainability, 13*, 7126. https://doi.org/10.3390/su13137126

Patil, H. Y., Karatangi, K. G., & Mutanal, S. M. (2017). Growth and productivity of *Melia dubia* under different plant density. *International Journal of Forestry & Crop Improvement, 8*(1), 30–33.

Quandt, A., Neufeldt, H., & Gorman, K. (2023). Climate change adaptation through agroforestry: Opportunities and gaps. *Current Opinion in Environmental Stability, 60*, 101244.

Shambharkar, V. B., Tandel, M. B., Gunaga, R. P., Sinha, S. K., Parekh, V. B., Garde, Y. A., Deshmukh, H. K., & Choudhari, S. W. (2024). A comparative study of crown spread variation in *Pterocarpus marsupium* and *P. santalinus*, across north-south aspects and diverse seed sources in India. *An International Refereed, Peer Reviewed & Indexed Quarterly Journal for Applied Science, 14*(52), 262–265.

Singh, V., Johar, V., Kumar, R., & Chaudhary, M. (2021). Socio-economic and environmental assets sustainability by agroforestry systems: A review. *International Journal of Agriculture Environment and Biotechnology, 14*(4), 521–533.

Tewari, V. P., & Singh, B. (2006). Total and merchantable wood volume equations for *Eucalyptus* hybrid trees in Gujarat state, India. *Arid Land Research and Management, 20*, 147–159.

Thakur, N. S., Gunaga, R. P., Hegde, H. T., Chauhan, R. S., Bhuva, D. C., & Bhusara, J. B. (2021). Development of biomass and volume models of *Melia dubia* Cav. for early establishment. *Indian Journal of Ecology, 48*(3), 698–701.

Thakur, N. S., Hegde, H. T., Chauhan, R. S., Gunaga, R. P., Kumar, A., Bhusara, J. B., & Bhuva, D. C. (2023). Growth, productivity, and genetic variability of some *Melia dubia* Cav. open pollinated families in Gujarat, India. *Indian Journal of Ecology, 50*(5), 1294–1301.

Thambi, S. (2024). Trees are good for tackling climate change, right? *Sustainability*. https://www.forbes.com/sites/simithambi/2024/06/12/trees-are-good-for-tackling-climate-change-right/ (cited on 19.09.2025).

UNDP. (2023). *UNDP annual report 2023*.

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/144495