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ORIGINAL ARTICLE

Growth, Biomass Production and Yield Variation in *Eucalyptus* Clones

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Eucalyptus are among the most widely cultivated forest trees in the world under a range of different climates for products that include pulp, paper fuel wood and solid wood products such as poles, furniture and construction timber. Productivity and profitability of plantations of Eucalyptus have been revolutionized with the development of genetically improved, fast growing and high yielding Clonal planting stock of Eucalyptus. Eucalyptus Clonal planting has been said to have advantages which includes quick provision of benefits associates with fast growth, short rotation for production of pulp wood (of around 70 MT ha-1 in 6 years) ready marketing and easy establishment and less maintenance needs. Clonal planting one among the approach for management of water and nutrients compared to the other conventional strategies. Studies relating to Clonal difference and evaluation for dry matter production will help to overcome productivity loss due to deficit rainfall and optimum utilization of available natural resources for higher wood production. The present study was carried out to test the hypothesis that there exists a Clonal variation in growth, biomass production and yield and the present study gives an insight in to Clonal variation in with reference to growth, biomass production and yield.

Key words: Eucalyptus clones, Growth, Productivity and Yield

Eucalypts are among the most widely cultivated forest trees in the world. The major Eucalyptus growing countries are China, India and Brazil. Growth rates that routinely exceed 35 m^3 ha^{-1} $year^{-1}$. These fast-growing plantations can be grown under a range of different climates for products that include pulp and paper, charcoal, fuel wood, and solid wood products such as poles, furniture, and construction timber. Being endemic to Australia, Southeast Asia, and the Pacific, eucalypts are grown mainly as exotic species (Davidson, 1995; Stape, 2002; 2010; ICFRE, 2010). Eucalyptus shows a broad productivity response depending on species, clones and soil factors (Onyekwelu *et al.,* 2011). Eucalyptus sp. has some of the highest net primary productivity rates up to 49 m^3 ha^{-1} $year^{-1}$ (Hubbard *et al.,* 2010). Mean annual increments of clone plantation of *Eucalyptus* sp. with no fertilization, with fertilization and fertilization combined with irrigation are 33, 46 and 62 m^3 ha^{-1} $year^{-1}$, respectively.

The high biomass accumulation potential makes *Eucalyptus sp*. a good prospect for timber, wood products and carbon sequestration projects. Clonal selection and deployment in Eucalyptus is receiving attention as an intensive forest management tool for increased wood production. Many pulp and paper and other wood based industries are now establishing clonal forestry program after the promulgation of 1988 National Forest Policy. The National Forest Policy has given clear cut indication that the forest based industries must prefer to raise required raw materials by themselves. The industries should establish direct relationship with individual growers of raw material by providing them credit, technical advice, harvesting and transport services. The policy also indicated that small and marginal farmers have to be encouraged to grow wood species required in forest based industries in their marginal and submarginal lands.

Eucalyptus clonal planting has been said to have advantages includes quick provision of benefits associated with fast growth, short rotation for production of pulp wood (about 70 M t ha^{-1}), ready marketing and other reasons. It is an important industrial species and now popularized among the farmers due to varies reasons especially climatic vagaries (erratic and shortage of total rainfall, variation in the distribution, etc.) and shortage of irrigation to agriculture. The clonal plantations are the one among the best option to meet out the ever increasing demand for paper and pulp wood. But there is a continuous depletion of the natural resources especially various nutrients from the soil due to its repeated rotation and fast growth in nature. Information on consumption of natural resources mainly water and nutrients for production of biomass and stem wood are not well documented especially in Eucalyptus clones.

Clonal planting is one among the approach for management of water and nutrients compared to the other conventional strategies. The clonal evaluation for growth, dry matter production and yield study will help to selection of site specific clones based on climatic and edaphic factors for obtaining optimum yield. Therefore the present study was undertaken to assess growth, dry matter production and yield of Eucalyptus clones along with the commercial clones available in the market at present and the seed origin seedlings for comparison purpose.

MATERIALS AND METHODS

Material:

To carry out the dry matter allocation study, Eucalyptus clones are selected as the experimental material. This includes 24 clones and two seed origin seedlings. Among the 24 clones, 16 clones are shortlisted by IFGTB and these clones are numbered from C-7 to C-196. For comparison purpose, 8 clones (6 ITC clones and 2 TNPL clones) and two seed origin seedlings (each one from Tamil Nadu Forest Plantation Corporation and IFGTB) are selected and named as check clone 1 to 10.

Establishment of field trials:

The Clonal field trials have been established and in total, 49 ramets were planted in a block per clone and 26 clones were planted in three replications in the espacement of 3 × 1.5 m. Growth parameters and physiological parameters were taken annually. During the half rotation period, biomass sampling has been carried out by adopting the stratified average tree technique. Samples from different components of

Eucalyptus clones such as leaves, branches, twigs, stem and root were collected and analyzed for various major nutrients. Dry matter production, volume and commercial volume of different Eucalyptus clones were worked out on single tree basis and converted to hectare (ha) basis. The sampling technique adopted in the present study was 'Stratified average tree technique' as proposed by Art and Marks (1971). In this technique, the girth at breast height of each tree in the replication was recorded. The whole girth class was grouped by frequency distribution method and an average tree of each replication was selected for sampling. Thus, the average trees were felled from each replication and estimated the above and below ground biomass.

RESULTS AND DISCUSSION

Growth parameters

For selection of high productive clones from the established clonal trials, the collected height values were analysed across the location and the grand mean height for different clones were presented in the Table-1. The grand mean of the Eucalyptus clones across the location was 7.3 m, while the average height varies from 5.0 to 9.3 m across the locations. At the half rotation period, C-188 registered highest average height growth of 9.3 m followed by C-19 (8.9 m), C-63 (8.7 m) and C-186 (8.6 m). The least height growth of 5.0 m was recorded in C-115 followed by 5.7 m in check clone 1 and 5.9 m in check clone 8. Though various clones registered variation in height parameters in different locations, clones C-188, C-186, C-123, C-14, C-10 and C-19 registered the maximum height of above 8.50 m and these clones registered greater grand mean height with low standard error values which implies that, within and across the trials, these are the preferable stable clones for large scale planting with reference to the total height, across the locations.

The girth at breast height data collected and analysed across the location and the average girth at breast height were presented in the Table-2. The grand mean girth of the Eucalyptus clones across the location was 19.5 cm. From the clonal trials established in four locations, C-19 registered the maximum girth of 25.9 cm followed by C-188 (25.6 cm) C-14 (24.6 cm), C-186 (24.4 cm), C-10 (23.6 cm) and C-123 (23.7 cm). When compared to the grand mean across the trial (19.5 cm) which is lower than the grand mean in Pudukottai, Karaikudi and Coimbatore, except in Tirunelveli. Clones of C-14, C-19, C-186 and C-188 recorded greater girth measurement more than 23.5 cm.

Kumar *et al.* (2010) also reported that, significant variations were recorded for height, diameter at breast height (DBH) and clear bole height (CBH) for eighteen clones of *E. tereticornis* for various growth parameters. The average genetic gain for three years was recorded maximum for height (159.60%) followed by DBH (110.97%) and CBH (70.34%). Clone 17 attained maximum DBH over other genotypes for second and third year followed by clones 14 and 11. There were significant differences between clones and sites for height and circumference and there were significant effect of interaction clone x site for circumference and height (Paulo Ricardo Gherardi Hein *et al*, 2010). Ginwal, (2009) studied the Provenance and family variation in growth performance of *E. tereticornis* and reported that, significant variation in plant height, clean stem height, girth at breast height (GBH). Within provenance individual tree heritability estimates for height, clean stem length, GBH and number of branches at age 3 years were 0.318, 0.215, 0.269 and 0.231, respectively (assuming a coefficient of relationship of 0.4 for open-pollinated families of *E. tereticornis*). Similarly significant differences in different Eucalyptus species have been reported by various workers. Lal (2005) conducted a study to assess the comparative growth performance of various Eucalyptus species. Kumar and Bangawa (2006) observed significant differences for growth attributes among seven species of Eucalyptus species. Xiaoyong Mo *et al.* (2003) studied the important traits and combined evaluation of Eucalyptus clones and revealed that, 17 clones were significantly taller than the mean of 27 clones by the average of 20.3%. The mean superiority in dbh of 17 clones was 18.4%. The minimum height and dbh were 6.5 m and 6.14, respectively.

Above, below ground and total biomass production

The difference in the AGB between the highest and the lowest in various clones in different clonal trials was worked out and the results were presented for across the location for the half rotation period (3 years). In the half rotation period (3rd year), the lowest AGB was recorded 5.55 kg tree^{-1} in C-124 and the highest AGB of 10.52 kg tree^{-1} in C-188. The highest above ground biomass was recorded in C-188, C-10, C-14, C-19, C-123 and C-186 and these clones are forming a single group. On the other hand, in the third year C-124 recorded the lowest BGB of 1.26 kg tree^{-1} and C-188 recorded the highest BGB of 2.44 kg tree^{-1} with the mean of 1.51 kg tree $^{-1}$. The clones of C-188, C-10, C-14, C-19, C-111 and C-186 are forming a single group and recorded the highest below ground biomass production among the different clones. Among the clones, C-124 registered the lowest below ground biomass followed by C-100 and check clone 7. In the case of total dry matter production C-100 registered the lowest total biomass production of 6.77 kg tree^{-1} and C-188 registered the highest total biomass of 12.99 kg tree^{-1} with the mean of 9.54 kg tree^{-1}.The clones C-188, C-186, C-19, C-10 and C-14 are forming a single group and registered the higher production of total biomass among the Eucalyptus clones. Clone C-100 registered the lowest total biomass of 6.77 kg tree^{-1} followed by C-124 (6.80 kg tree^{-1}) and check clone 1 (7.23 kg tree^{-1}) compared to the mean (Table-3).

The mean annual increment from these plantations of selected clones after six years was recorded to 35 m^3 ha^{-1} yr^{-1} as compared to 20-25 m^3 ha^{-1} yr^{-1} from selected provenance and about 12 m^3 ha^{-1} yr^{-1} from unselected seed lots reported by Praveen *et al*, (2010) in Eucalyptus hybrids. Dry matter production is directly related to the growth parameters and the clones are recorded higher production of the dry matter content compared to the seedling origin seedlings.

Individual biomass components

In the case of third year, the leaf biomass ranged from 0.79 kg tree^{-1} in C-124 to 1.49 kg tree^{-1} in C-188 followed by 1.42 kg tree^{-1} in C-186 with the mean of 1.11 kg tree^{-1}; branch biomass ranged from 1.22 kg tree^{-1} in C-100 to 2.36 kg tree^{-1} in C-188 followed by 2.23 kg tree^{-1} in C-186 and C-19 with the mean of 1.73 kg tree^{-1}. In the case of stem wood biomass, C-124 registered the lowest biomass of 3.50 kg tree^{-1} and C-188 recorded the highest biomass of 6.67 kg tree^{-1} followed by C-19 (6.38 kg tree^{-1}) with the mean of 4.86 kg tree^{-1}. Clone C-124 recorded the lowest root biomass of 1.26 kg tree^{-1} and C-188 recorded the highest root biomass of 2.44 kg tree^{-1} followed by 2.27 kg tree^{-1} in C-186 with the mean of 1.79 kg tree^{-1} in the case of root biomass production (Table-4).

Studies in *C. equisetifolia* in Puerto Rico revealed that, the percentage contribution of stem wood was highest (76%) when compared to other components. Relatively higher percentage of bole was reported in *C. equisetifolia* by Verma (1987), Jambulingam (1989) and Srivastava (1994). Similar results are also reported by Singh *et al*. (2010), 76.8% in *E. teriticornis* and 72.9% in *Pithecellobium dulce* and Wang *et al*. (1995) in *Populus tremuloides*. Vidyasegran (2003) reported similar percentage of root biomass of *C. equisetifolia* from 18.97 to 22.5%. Buvaneswaran (2004) reported that the percentage of root biomass to total biomass increased from 17.0 to 30.0% for teak in Southern dry and western moist agro-climatic zones of Tamil Nadu. With regard to review of bgb in different species, Zabek and Prescott (2006) reported 13-26% of root biomass to total plant biomass in Hybrid poplar. Dhyani *et al*. (1990) found that root weight ranged from 22% (*L. leucocephala*) to 29% (*E. teriticornis*) of total tree biomass in a comparison of five tree species at 2 years of age.

Total volume and stem wood yield of the Eucalyptus clones

With reference to the volume and stem wood production, clone C-188 registered the maximum volume and stem wood yield of 30.60 m^3 ha^{-1} and 21.14 t ha^{-1}. The clone C-100 recorded the minimum of 16.93 m^3 ha^{-1} and 11.73 t ha^{-1}, across the location (Table-5).

Luna *et al.* (2009) stated that the productivity of ITC *Eucalyptus* clones and the clone 413 gave the maximum MAI (mean annual increment) of 28.80 m^3 ha^{-1} yr $^{-1}$, over bark and 23.49 m^3 ha^{-1} yr $^{-1}$, under bark, at an age of 3 years. The clone 526 performed better at Gurdaspur with maximum MAI (productivity) of 21.15 m^3 ha^{-1} yr $^{-1}$, over bark and 17.25 m^3 ha^{-1} yr $^{-1}$, under bark. Whereas, at Amritsar, clone 413 was most productive with MAI of 36.07 m^3 ha^{-1} yr $^{-1}$, over bark and 29.42, m^3 ha^{-1} yr $^{-1}$, under bark, at the age of 2.5 years. The present study revealed that the clone 413 gave outstanding productivity over bark ranging from 28.80 to

36.07 m^3 ha^{-1} year $^{-1}$. Clone 288 gave MAI of 48.79 m^3 ha^{-1} yr^{-1}over bark, followed by clone 316 with MAI to the tune of 33.70 m^3 ha^{-1} yr^{-1} at the age of 4 and 5 years, respectively.

The range in productivity recorded for different Eucalyptus clones in the present study across the location (24.29 m^3ha^{-1} to 122.19 m^3ha^{-1} in 3 years) was compared that of other species of commercial importance. This variation occurs due to location effect includes edaphic and climatic factors. This range in productivity was observed in other species like *D. sissoo* – 7.8 MT $ha^{-1}yr^{-1}$ (Sharma *et al.,* 1998), *G. arborea* – 8.2 MT $ha^{-1}yr^{-1}$(Negi *et al.,* 1990), *Tectona grandis* – 3 to 12 MT ha^{-1} yr^{-1} (Buvaneswaran, 2004), clones of *Populas deltoides* – 14.6 MT $ha^{-1}yr^{-1}$ (Fang *et al.,* 2007), *Eucalyptus hybrid* – 14.2 MT $ha^{-1}yr^{-1}$ (George, 1977) and *Acacia mangium* – 22.6 MT $ha^{-1}yr^{-1}$ (Tsai, 1988). Singh and Tokey (1995) reported that 8 years old plantations of *Eucalyptus tereticornis, Leucaena leucocephala* and *Acacia nilotica* had productivity of 21, 25 and 14 MT $ha^{-1}yr^{-1}$ respectively.

Table 1. Average height grand mean girth of Eucalyptus clones in different clonal trials

Clone ID	Average height of Eucalyptus clones (m)				Grand mean (m)
	Pudukottai	Karaikudi	Tirunelveli	Coimbatore	
C 7	10.0 ± 0.5	7.8 ± 0.5	7.6 ± 0.2	7.9 ± 0.1	8.3 ± 0.6
C 9	5.9 ± 0.5	6.6 ± 0.5	5.8 ± 0.2	6.5 ± 0.1	6.2 ± 0.2
C 10	10.7 ± 0.5	7.8 ± 0.5	7.1 ± 0.3	8.1 ± 0.3	8.7 ± 0.8
C 14	7.5 ± 0.4	8.6 ± 0.4	7.3 ± 0.1	10.0 ± 0.2	8.7 ± 0.6
C 19	9.2 ± 0.5	10.0 ± 0.5	7.9 ± 0.2	8.4 ± 0.2	8.9 ± 0.5
C 63	8.4 ± 0.5	7.9 ± 0.5	8.0 ± 0.1	8.3 ± 0.1	8.6 ± 0.6
C 66	7.6 ± 0.5	7.0 ± 0.5	6.4 ± 0.1	6.8 ± 0.2	6.9 ± 0.3
C 100	7.1 ± 0.4	7.4 ± 0.5	6.7 ± 0.1	7.1 ± 0.3	7.1 ± 0.1
C 111	8.9 ± 0.4	9.1 ± 0.4	7.6 ± 0.2	8.1 ± 0.1	8.4 ± 0.4
C 115	4.4 ± 0.2	5.4 ± 0.2	4.6 ± 0.3	5.5 ± 0.4	5.0 ± 0.3
C 123	7.9 ± 0.4	8.0 ± 0.4	9.2 ± 0.3	8.4 ± 0.2	8.4 ± 0.3
C 124	8.4 ± 0.6	7.3 ± 0.6	6.7 ± 0.1	7.0 ± 0.1	7.4 ± 0.4
C 186	8.9 ± 0.7	8.8 ± 0.5	7.7 ± 0.2	9.2 ± 0.2	8.6 ± 0.3
C 187	8.4 ± 0.4	8.1 ± 0.4	7.2 ± 0.2	7.9 ± 0.3	7.9 ± 0.3
C 188	11.6 ± 0.2	8.7 ± 0.2	8.3 ± 0.2	8.4 ± 0.2	9.3 ± 0.3
C 196	8.6 ± 0.4	8.0 ± 0.4	7.7 ± 0.1	8.7 ± 0.3	8.4 ± 0.4
Check 1	5.9 ± 0.4	5.5 ± 0.4	5.3 ± 0.2	6.0 ± 0.2	5.7 ± 0.2
Check 2	6.3 ± 0.4	6.0 ± 0.4	5.5 ± 0.1	6.4 ± 0.2	6.0 ± 0.2
Check 3	6.5 ± 0.4	5.9 ± 0.4	6.2 ± 0.1	6.8 ± 0.2	6.4 ± 0.2
Check 4	8.3 ± 0.6	7.4 ± 0.6	7.1 ± 0.1	7.3 ± 0.4	7.5 ± 1.3
Check 5	7.5 ± 0.4	6.6 ± 0.4	6.8 ± 0.2	7.2 ± 0.2	7.0 ± 0.2
Check 6	6. 7 ± 0.7	6.1 ± 0.7	6.2 ± 0.13	6.1 ± 0.4	6.3 ± 0.1
Check 7	7.6 ± 0.2	6.4 ± 0.2	6.0 ± 0.1	7.6 ± 0.2	6.9 ± 0.4
Check 8	6.4 ± 0.2	5.4 ± 0.2	5.8 ± 0.2	6.1 ± 0.1	5.9 ± 0.2
Check 9	6.8 ± 0.2	5.5 ± 0.4	5.4 ± 0.2	6.1 ± 0.3	6.0 ± 0.3
Check 10	5.8 ± 0.4	5.5 ± 0.4	5.5 ± 0.1	6.3 ± 0.1	6.0 ± 0.2
Grand Mean	**7.8**	**7.2**	**6.6**	**7.4**	**7.3**
SED	0.59	0.42	0.26	0.33	0.46

* Mean height value with ± Standard Error.

Table 2. Average Girth at breast height grand mean girth of Eucalyptus clones in different clonal trials

Clone ID	Average girth of Eucalyptus clones (cm)				Grand mean girth (cm)
	Pudukottai	Karaikudi	Tirunelveli	Coimbatore	
C 7	25.3 ± 0.9	22.7 ± 1.5	16.3 ± 0.7	22.5 ± 1.5	22.0 ± 1.7
C 9	20.7 ± 1.2	20.7 ± 1.5	15.6 ± 0.3	20.7 ± 1.2	19.8± 0.9
C 10	28.3 ± 1.2	24.8 ± 1.5	20.3 ± 0.7	22.6 ± 0.9	23.6 ± 2.0
C 14	23.6 ± 1.9	23.3 ± 0.7	21.6 ± 0.3	30.7 ± 1.8	24.6 ± 2.2
C 19	24.7 ± 1.5	32.2 ± 1.9	19.6 ± 1.7	26.0 ± 1.2	25.9 ± 2.6
C 63	18.5 ± 1.5	16.6 ± 1.2	23.3 ± 2.3	22.0 ± 1.5	19.5 ± 1.2
C 66	17.3 ± 1.8	18.0 ± 2.1	14.0 ± 1.0	17.3 ± 1.2	17.1 ± 0.5
C 100	13.6 ± 1.8	15.0 ± 1.7	12.3 ± 0.3	14.0 ± 1.1	14.0 ± 0.4
C 111	23.0 ± 1.5	27.3 ± 1.8	20.0 ± 1.0	22.6 ± 0.9	16.6 ± 1.7
C 115	16.2 ± 1.5	17.6 ± 0.9	15.0 ± 1.0	17.7 ± 1.2	15.7 ± 0.8
C 123	22.6 ± 1.2	22.5 ± 0.9	28.0 ± 1.0	22.7 ± 0.7	23.7 ± 1.0
C 124	14.8 ± 1.5	16.5 ± 1.2	12.6 ± 0.7	17.8 ± 1.5	15.4 ± 0.9
C 186	23.7 ± 1.5	25.0 ± 1.5	17.6 ± 0.3	29.0 ± 0.6	24.4 ± 2.1
C 187	21.6 ± 1.5	22.3 ± 1.2	18.3 ± 0.7	21.7 ± 0.9	20.6 ± 1.7
C 188	32.7 ± 0.9	23.6 ± 1.5	25.0 ± 1.0	23.3 ± 0.9	25.6 ± 2.3
C 196	20.6 ± 1.2	20.6 ± 1.5	17.3 ± 0.3	27.6 ± 0.9	16.2 ± 2.4
Check 1	13.6 ± 1.8	15.6 ± 1.5	12.3 ± 1.3	16.7 ± 0.9	14.8 ± 0.8
Check 2	15.3 ± 1.8	17.0 ± 1.0	15.4 ± 0.3	17.7 ± 1.2	18.3 ± 0.7
Check 3	15.7 ± 1.8	13.3 ± 1.3	12.7 ± 0.7	16.3 ± 0.9	15.6 ± 0.7
Check 4	23.6 ± 1.3	21.3 ± 1.6	19.6 ± 0.7	21.6 ± 1.5	21.4 ± 1.0
Check 5	22.6 ± 0.9	21.3 ± 0.9	19.7 ± 0.3	21.0 ± 1.5	20.8 ± 1.0
Check 6	19.6 ± 1.5	20.6 ± 1.2	16.3 ± 0.3	15.3 ± 0.9	16.0 ± 1.2
Check 7	14.3 ± 1.2	15.5 ± 0.7	13.4 ± 0.7	16.7 ± 1.2	15.0 ± 0.7
Check 8	16.1 ± 1.5	14.3 ± 1.2	14.0 ± 1. 0	15.3 ± 1.2	16.2 ± 0.7
Check 9	17.0 ± 1.7	15.6 ± 1.2	14.3 ± 1.3	16.0 ± 0.6	15.6 ± 0.5
Check 10	15.5 ± 1.5	17.6 ± 1.2	12.7 ± 0.3	16.7 ± 0.5	15.5 ± 0.9
Grand Mean	**20.1**	**20.1**	**17.1**	**20.5**	**19.5**
SED	2.12	1.91	1.31	1.56	1.64

* Mean height value with ± Standard Error.

Table 3. Above Ground Biomass, Below Ground Biomass and total biomass (kg tree-1) production of Eucalyptus clones across the location in three year old plantation.

Clone	AGB	BGB	Total Biomass
C 7	8.87$^{f-g-h-i}$	2.07$^{e-f-g-h}$	10.94^{g-h-i}
C 9	8.26^{e-f-g}	1.87^{d-e-f}	10.14^{e-f-g}
C 10	9.82^{i-j-k}	2.21^{g-h-i}	11.73^{i-j-k}
C 14	9.81^{i-j-k}	2.16^{g-h-i}	11.98^{i-j-k}
C 19	9.95^{j-k}	2.22^{g-h-i}	12.16^{j-k}
C 63	8.87$^{f-g-h-i}$	1.97^{e-f-g}	10.84$^{f-g-h-i}$
C 66	7.90^{d-e-f}	1.79^{d-e}	9.63^{d-e-f}
C 100	5.49^{a}	1.28^{a}	6.77^{a}
C 111	8.45^{e-f-g}	2.16^{g-h-i}	10.61^{f-g-h}
C 115	6.47^{a-b-c}	1.44^{a-b-c}	7.91^{a-b-c}
C 123	9.82^{i-j-k}	2.15^{f-g-h}	11.97^{i-j-k}
C 124	5.55^{a}	1.26^{a}	6.80^{a}
C 186	9.96^{j-k}	2.27^{h-i}	12.24^{j-k}
C 187	8.63^{f-g-h}	1.97^{e-f-g}	10.60^{f-g-h}
C 188	10.52^{k}	2.44^{i}	12.99^{k}
C 196	8.82$^{f-g-h-i}$	2.01$^{e-f-g-h}$	10.83$^{f-g-h-i}$
Check 1	5.81^{a}	1.42^{a-b-c}	7.23^{a}
Check 2	5.96^{a}	1.45^{a-b-c}	7.41^{a-b}
Check 3	6.18^{a-b}	1.51^{a-b-c}	7.69^{a-b}
Check 4	6.94^{b-c-d}	1.59^{b-c-d}	8.53^{b-c-d}
Check 5	7.31^{c-d-e}	1.65^{c-d-}	8.97^{c-d-e}
Check 6	6.94^{b-c-d}	1.62^{c-d}	8.56^{b-c-d}
Check 7	5.69^{a}	1.32^{a-b}	7.02^{a}
Check 8	7.47^{d-e}	1.82^{d-e}	9.30^{d-e}
Check 9	6.04^{a-b}	1.48^{a-b-c}	7.52^{a-b}
Check 10	6.16^{a-b}	1.51^{a-b-c}	7.67^{a-b}
Mean	**7.76**	**1.79**	**9.54**

Table 4. Mean dry matter production (kg tree-1) of various biomass components in Eucalyptus clones during 3rd year of growth across four locations of study.

Dry matter production (kg tree^{-1})				
Clones	**Leaf**	**Branch**	**wood**	**Root**
C 7	1.29^{g}	2.02b$^{g-h-I-j}$	5.56$^{g-h-I-j}$	2.07$^{e-f-g-h}$
C 9	1.14^{e-f}	1.84^{e-f-g}	5.28^{e-f-g}	1.87^{d-e-f}
C 10	1.36^{g-h-i}	2.12^{h-I-j}	6.34$^{h-I-j-k}$	2.21^{g-h-i}
C 14	1.43^{i-j}	2.20^{I-j-k}	6.18^{I-j-k}	2.16^{g-h-i}
C 19	1.34^{g-h-i}	2.23^{j-k}	6.38^{j-k}	2.22^{g-h-i}
C 63	1.30^{g-h}	1.98^{g-h-i}	5.59$^{f-g-h,i}$	1.97^{e-f-g}
C 66	1.16^{e-f}	1.76^{d-e-f}	4.98^{d-e-f}	1.79^{d-e}
C 100	0.77^{a}	1.22^{a}	3.5^{a}	1.28^{a}
C 111	1.35^{g-h-i}	2.15^{I-j-k}	4.95^{I-j-k}	2.16^{g-h-i}
C 115	0.92^{b-c}	1.45^{a-b-c}	4.1^{a-b-c}	1.44^{a-b-c}
C 123	1.43^{I-j}	2.19^{I-j-k}	6.2^{I-j-k}	2.15^{f-g-h}
C 124	0.79^{a-b}	1.24^{a}	3.5^{a}	1.26^{a}
C 186	1.42^{h-I-j}	2.23^{j-k}	6.31^{j-k}	2.27^{h-i}
C 187	1.24^{f-g}	1.93^{f-g-h}	5.46^{f-g-h}	1.97^{e-f-g}
C 188	1.49^{j}	2.36^{k}	6.67^{k}	2.44^{i}
C 196	1.24^{f-g}	1.98$^{f-g-h-i}$	5.6$^{f-g-h-i}$	2.01$^{e-f-g-h}$
Check 1	0.82^{a-b}	1.30^{a}	3.69^{a}	1.42^{a-b-c}
Check 2	0.84^{a-b}	1.33^{a-b}	3.79^{a-b}	1.45^{a-b-c}
Check 3	0.87^{a-b-c}	1.38^{a-b}	3.93^{a-b}	1.51^{a-b-c}
Check 4	0.97^{c-d}	1.55^{b-c-d}	4.42^{b-c-d}	1.59^{b-c-d}
Check 5	1.08^{d-e}	1.63^{c-d-e}	4.6^{c-d-e}	1.65^{c-d-}
Check 6	0.97^{c-d}	1.55^{b-c-d}	4.42^{b-c-d}	1.62^{c-d}
Check 7	0.82^{a-b}	1.27^{a}	3.6^{a}	1.32^{a-b}
Check 8	1.08^{d-e}	1.67^{d-e}	4.72^{d-e}	1.82^{d-e}
Check 9	0.86^{a-b-c}	1.35^{a-b}	3.83^{a-b}	1.48^{a-b-c}
Check 10	0.87^{a-b-c}	1.38^{a-b}	3.91^{a-b}	1.51^{a-b-c}
Mean	**1.11**	**1.73**	**4.86**	**1.79**

Table 5. Volume (m3 ha-1) and wood yield (t ha-1) on fresh weight basis for different clones of Eucalyptus.

Clone ID	3rd year	
	Volume (m^3 ha^{-1})	**Yield (t ha^{-1})**
C 7	27.35	18.63
C 9	25.35	17.69
C 10	29.33	21.24
C 14	29.95	20.70
C 19	30.40	21.37
C 63	27.10	18.73
C 66	24.08	16.68
C 100	16.93	11.73
C 111	26.53	16.58
C 115	19.78	13.74
C 123	29.93	20.77
C 124	17.00	11.75
C 186	30.60	21.14
C 187	26.50	18.29
C 188	32.48	22.34
C 196	27.08	18.76
Check 1	18.08	12.36
Check 2	18.53	12.70
Check 3	19.23	13.17
Check 4	21.33	14.81
Check 5	22.43	15.41
Check 6	21.40	14.81
Check 7	17.55	12.06
Check 8	23.25	15.81
Check 9	18.80	12.83
Check 10	19.18	13.10
Mean	**23.85**	**16.43**

CONCLUSION

Genetic variation and environmental heterogeneity fundamentally shape the interactions between plants of the same species. Many authors reported that, significant differences between clones and sites for height, GBH, dry matter production and yield. There were significant effect of interaction between clones x site for height, GBH, dry matter production and yield. These findings can be useful for screenings, classifications, or preliminary selections in breeding programs of Eucalyptus. This disparity could also reflect in high variability in height, GBH, dry matter production and yield of clones in the same age. Further, this study confirms that, the clonal material exhibits better growth performance in terms of height as well as in girth, compared to the seedlings of seed origins, mainly due to the genetic characters of the materials.

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