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Genetic variation in growth attributes and pulp yield in eucalypts clones

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Abstract
Eucalyptus is one of the fast growing pulp wood species grown across the country. Many breeders working hard for developing high yielding genotypes across different site situations. In the present study, total 18 clones of eucalypts were evaluated for growth at the age of four years. Significant variation in growth parameters viz., tree height, diameter at breast height, tree volume and stem biomass was recorded in the studied clones. Among 18 clones, EC-4, EC-5, EC-8, EC-10 and EC-12 showed superiority for growth and stem biomass. Further, these five clones were assessed for pulp productivity and result showed that, there was a meager difference in pulp yield i.e., about 46 to 48 per cent among five clones. Interestingly, holocellulose and lignin content does not vary significantly among five clones. Data revealed that all these five clones found to be superior for both growth and pulp yield and they were suggested for commercial plantation in Navsari agro-ecological situations.

Keywords: Clonal evaluation, eucalyptus, growth attributes, pulp yield

Introduction
Eucalyptus is one of the commercial important exotic forest resources of the country. It is widely popular because of its fast growth, straightness with clear bole, short rotation and good coppicing ability. In fact, this species is grown in varieties of site situations for production of pulp and paper as well as rayon. About one million hectares of eucalypts plantations are managed by forest departments and forest development corporations in India. *Eucalyptus tereticornis* and *E. camaldulensis* are the major species grown in arid regions of the country. The State of Gujarat is one of the fastest growing states of India, especially in industrial sector. The demand for wood and wood products in Gujarat is increasing with the increasing industrialization and population. There is net annual deficit of 1 lakh metric tonnes of pulp wood from domestic supply (Huse *et al*., 2012) [6]. In Gujarat, forest department, private pulp and paper industries are raising *Eucalyptus* plantation commercially across the state for pulp and paper and as pole for construction purpose. By looking into the economical benefit and early rotation, several farmers of the state are growing eucalypts in their farmland as block plantation and on the farm bunds.

Eucalyptus improvement work was initiated in 1960s in the country (Kaikini 1961 and Venkatesh and Kedharnath, 1965) [7, 17]. Initially, plantations are raised by seedling source with rotation of six to eight years, followed by coppiced source for two rotations. Later, clonal technology changed the productivity potentially of pulp wood up to 3 to five times greater over plantation raised by seedling source. For instance, Kulkarni (2014) [11] reported higher productivity of clonal eucalyptus plantation *i.e.*, 20-58 t ha-1 yr-1 as compared to plantations raised using seedling origin (6-10 t ha-1 yr-1). Similarly, Krishnakumar *et al.* (2014) [9] also reported that, at the age 6 to 7 years rotation, the productive potential of eucalyptus clone was 60 to 70 t ha-1 in Tamil Nadu and it may goes up to 70 to 80 t ha-1 with introduction of new eucalypt clones. The productive potential of wood is also depends upon the site and climate. Therefore, evaluation of site specific clones for higher growth, productivity and pulp quality parameters is essential. On other hand, the climatic conditions prevailing in South Gujarat are quite favourable for growing eucalypts and casuarina. This also has synergistically attracted the farmers of south Gujarat for eucalypts and casuarinas cultivation in the farmland or cultivable lands (Huse *et al.*, 2012) [6]. Therefore, the study was carried out to assess the genetic potential of 18 eucalypt clones for growth attributes at the age of 4 years under South Gujarat heavy rainfall zone 1 (Agroecological situation-III) condition and best five selected clones were tested for quality pulp yield.

Materials and Methods

The experiment location belongs to tropical climate characterized by fairly hot summer, moderately cold winter and more humid and warm monsoon with heavy rainfall. The average annual precipitation is 1355 mm.

In the interest of farmers, a clonal eucalyptus trial was established in the year 2011 in the campus of College of Forestry, Navsari Agricultural University, Navsari, Gujarat [20^0 55′ 21.18″ N latitude, 72^0 54′ 29.24″ E longitude and at an altitude of 12 meters above mean Sea Level] and the trial composed of 18 *Eucalyptus* clones planted at 2 x 2 m spacing during June 2011 with three replications following randomized block design. The detail of the clonal material is given in the Table 1.

Growth observations such as tree height, diameter at breast height, tree volume and stem biomass were recorded from total six ramets (trees) per clone. Based on the performance of growth and biomass, out of 18 clones, five best clones were selected and studied for pulp characteristics. The entire log of individual clone was used for pulping and total pulp yield was recorded. Proximate pulp characters *viz.,* holocellulose and lignin content were also analysed following standard procedure (Anon. 1998a and Anon. 1998b) [1, 2]. The data regarding total pulp yield, lignin content and holocellulose content have been extrapolated to yield in metric tonnes per hectare.

Results and Discussion

Variation in Growth

In the present study, all the growth attributes such as tree height, DBH, volume and biomass showed significant variation among 18 eucalypt clones at the age of four years ($P < 0.05$). Maximum tree height was recorded by clone EC-8 (18.43 m), followed by EC-4, EC-1, EC-12, EC-5, EC-9, EC-14 and EC-11, which were statistically at par with former clone. However, EC-15 recorded minimum tree height of 13.35 m. Variation in DBH was recorded and it varied from 8.21 (EC-15) to 15.78 cm (EC-8). Similarly, tree volume also varied greatly and it ranged from 0.049 (EC-17) to 0.257 m^3 $tree^{-1}$ (EC-8). In the study, stem biomass production varied significantly and it ranged from 25.52 to 125.49 kg $tree^{-1}$. Overall result showed that, among 18 clones, EC-8, followed by EC-4, EC-10, EC-5 and EC-12 showed genetic superiority for growth and yield attributes parameters as compared to rest of the clones.

Such strong significant variation among clones of Eucalyptus has already been reported across the country. Behera (2015) [3] reported significant variation for tree height (18.77 to 23.86 m), DBH (11.95 to 16.85 cm) and volume (0.14 to 0.32 m^3 $tree^{-1}$) among 20 *Eucalyptus* clones at the age of about six years planted at a distance of 2 x 2 m. Further, Kaur and Saxena (2002) [8] tested performance of *E. tereticornis* clones in two agro-climatic situations in Haryana, India. They revealed that there was a great variation among 13 clones for growth performance such as height (14.90 to 23.15 m), DBH (15.92 to 21.01 cm) and clear bole height (4.85 to 16.90 m) at 7 years age planted at 3 x 3 m spacing. However, the overall performance of our clones showed better performance as compared to studies conducted by Kaur and Saxena (2002) [8]. Kulkarni (2010) [10] reported that ITC Bhadrachalam has made a comprehensive effort especially for clonal selection and propagation in eucalypts. Among several selected clones, ITC-411, ITC-413 and ITC-7 have reached to thousands of hectare in south India. Such clonal variation for growth and yield performance among *Eucalyptus* species was also reported by several scientists (Lal *et al.,* 2006; Luna and Singh, 2009; Huse *et al.,* 2012) [12, 14, 6] indicating the tremendous scope for further improvement of *Eucalyptus* for higher yield and production potential in India. Some of the clones studied showed better performance at the age four as compared to reviewed data. Variation recorded in growth attributes among 18 clones could be due to genetics and these clones may be used for further breeding and commercial plantation in south Gujarat condition.

Pulp Yield

In the study, total pulp yield, screen yield, holocellulose content and lignin content were assessed among five selected superior clones. The entire log is used for assessment of pulp yield. The present study shows that there was a meager difference among selected five clones for pulp quality (Table 3). The values of total pulp yield ranged from 46.20 (EC-12) to 47.80 per cent (EC-18) with overall mean of 47.14 per cent among five clones. Holocellulose and lignin content does not show significant variation among five clones. However, based on numerical value, the holocellulose content varied from 66.75 to 70.71 per cent, whereas lignin content varied from 24.77 to 26.10 per cent. Overall result showed that all the five clones showed superiority for their pulp quality and yield. Mahajan *et al.* (2000) [15] also evaluated eucalypt hybrid clones based on pulp yield. They reported that the superior clones produced the pulp yield of 43 to 48 per cent, whereas Vennila *et al.* (2011) [18] also studied clonal variation for pulp quality and the total pulp yield ranged from 40-48 per cent with kappa number of 19.30 to 23.40. Similarly, Chezhian *et al.* (2017) [4] evaluated 44 eucalypts hybrids with their parents (*E. pellita*, *E. tereticornis*, *E. camaldulensis* and *E. camaldulensis*) for pulp yield and hybrids clones namely TNPL HP-41, TNPL HP-4 and TNPL HP-4 showed better performance for pulp yield (47.2 to 48.1 %). Performance of our clones also showed better performance and they are in line with higher side range as per the reported pulp yield of 40 to 48 per cent (Mahajan *et al.,* 2000; Vennila *et al.,* 2011 and Chezhian *et al.,* 2017) [15, 18, 4]. Values of lignin and holocellulose content recorded in the study are in line with reported literatures, where Laxmikanth (2002) [13] recorded holocellulose with range of 69.5 to 85.2 per cent and lignin with range of 16.5 to 34.0 per cent among 75 trees of eucalypts (62 of *E. tereticornis* and 13 of *E. grandis*). Similarly, Resquin *et al.* (2006) [16] also documented variation among clones of *E. globulus* for holocellulose and it ranged from 69 to 72 per cent.

Besides this, Guha (1969) [5] grouped the paper making properties of tropical hardwoods based on pulp yield and breaking length parameters, where pulp yield > 48% with breaking length of >6 km considered as very good, while for good category, the pulp yield and breaking length should be of 45 to 48 % and 5-6 km, respectively. However, for fair, the pulp yield and breaking length should be 39-45 % & 4.8-5.0 km, respectively and for low, they should be <39% & <4.8 km, respectively. Considering pulp yield of our clones, all the five clones belonged to the good category, where these clones produced pulp yield in between 45 and 48%.

Estimated Pulp Productivity

Further, data of pulp yield extrapolated to yield per ha and details are given Fig. 1. All these three characters showed significant variations among the selected five clones. The estimated total pulp yield ranged from 96.98 to 168.89 MT ha^{-1}. Similarly, estimated total holocellulose ranged from 135.03

to 258.95 MT ha^{-1} with lignin content ranged from 51.16 to 91.26 MT ha^{-1} (Fig. 1). The overall pulp productivity of these five clones was estimated to be 118.01 MT ha^{-1}. One of the reports showed that one hectare of eucalyptus plantation may produce 10 to 12 tonnes of bleached pulp annually from average growth rate of 35-45 m^3 ha^{-1} yr^{-1} in Brazil situation (www.celso-foelkel.com.br) [19] This shows that, our estimated yield found to be more than reported yield.

Conclusion

Study concludes that growth parameters such as tree height, diameter at breast height, tree volume and stem biomass recorded significant variation among 18 eucalypt clones and clones such as EC-4, EC-5, EC-8, EC-10 and EC-12 showed superior performance for growth, especially stem biomass. All these five clones does not show significant variation for pulp quality and yield indicating all the five clones found to be good for pulp yield, which contributed 45 to 48 per cent pulp yield. Hence these five clones are suggested for further breeding and commercial plantation under Navsari agroclimatic condition.

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Table 1: Clonal identity of 18 commercial Eucalypt clones used in the study

S. No	Treatment	S. No	Treatment	S. No	Treatment
1.	EC-1	7.	EC-7	13.	EC-13
2.	EC-2	8.	EC-8	14.	EC-14
3.	EC-3	9.	EC-9	15.	EC-15
4.	EC-4	10.	EC-10	16.	EC-16
5.	EC-5	11.	EC-11	17.	EC-17
6.	EC-6	12.	EC-12	18.	EC-18

Table 2: Clonal variation for growth parameters among 18 Eucalypts clones

Clone	Tree Height (m)	DBH (cm)	Tree Volume (m^3)	Stem biomass production (kg/tree)
EC-1	17.92	12.93	0.150	78.78
EC-2	15.63	11.18	0.111	79.80
EC-3	15.79	11.53	0.111	75.51
EC-4	18.06	13.13	0.178	108.02
EC-5	17.82	11.82	0.132	91.92
EC-6	15.51	11.00	0.103	53.54
EC-7	16.32	12.89	0.120	71.32
EC-8	18.43	15.78	0.257	162.49
EC-9	17.43	9.74	0.094	71.09
EC-10	16.33	13.74	0.144	96.52
EC-11	17.06	13.43	0.156	78.78
EC-12	17.92	10.08	0.101	87.80
EC-13	16.09	12.71	0.149	78.80
EC-14	17.23	9.28	0.087	72.89
EC-15	13.35	8.21	0.055	35.43
EC-16	15.15	9.68	0.079	40.31
EC-17	13.82	8.94	0.049	40.48
EC-18	14.48	9.63	0.065	39.52
Mean	16.35	11.43	0.119	75.72
SEm (±)	0.64	0.99	0.020	4.09
CD at 5%	1.85	2.87	0.058	11.82
CV (%)	6.82	15.08	29.40	9.36

Table 3: Clonal variation for pulp characterization among five selected Eucalypt clones at 4 years age

Clone	Pulp yield (%)		Lignin (%)	Holocellulose (%)
	Total yield	Screen yield		
EC-4	47.80	47.40	25.34	67.56
EC-5	47.20	46.80	26.10	65.72
EC-8	46.20	45.70	24.82	70.42
EC-10	47.10	46.70	25.84	66.75
EC-12	47.40	46.90	24.77	70.71
Mean	47.14	46.70	25.37	68.23
SEm (±)	-	-	0.54	1.41
CD at 5%	-	-	NS	NS
CV (%)	-	-	3.66	3.58

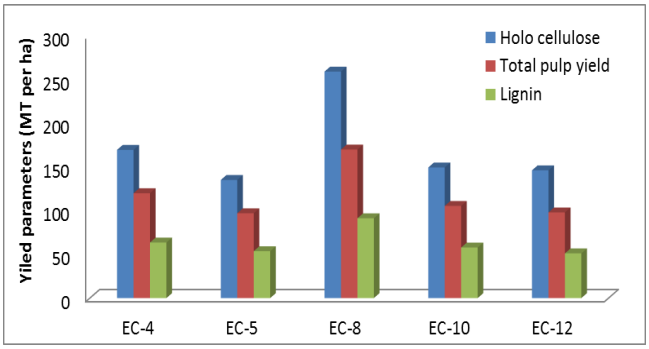

Fig 1: Genetic variation in pulp characteristics (MT ha^{-1}) among five eucalypt clones

References

1. Anonymous. TAPPI T222 om-98. Acid-insoluble lignin in wood and pulp. TAPPI Press, Atalanta, GA. (cited in: https://imisrise.tappi.org/TAPPI/Products/01/T/0104T222.aspx), 1998a.
2. Anonymous. TAPPI T9 m-54. Holocellulose in wood. TAPPI Press, Atalanta, GA. (cited in: http://www.tappi.org), 1998b.
3. Behera LK. Clonal variation for physical, anatomical and chemical properties of wood in *Eucalyptus*. Ph.D. (Forestry) Thesis. Navsari Agricultural University, Navsari, 2015.
4. Chezhian P, Venkatesan G, Selvakrishnan P, Seenivasan. Development and intra and interspecific hybrids in Eucalypts through AIP technique. In: Parthiban, K. T. and Seenivasan, R. 2017. Eds. Plantation and Agroforestry; Pulpwood value chain approach. Scientific Publishers, Jodhpur, 2017, 133-149.
5. Guha SRD, Nath P, Mathur GM. Neutral sulphite semi-chemical pulps from *Eucalyptus grandis*. Indian Forester. 1969; 95(5):353-355.
6. Huse SA, Jadeja DB, Rajpoot RS, Kumar V. Growth performance of twelve eucalyptus clnones in South Gujarat. In: Proceedings of National seminar on Agroforestry. Navsari Agricultural University, Navsari. 2012, 304-301.
7. Kaikini NS. *Eucalyptus* in Mysore state. *In:* Proceedings of the tenth All India Silvicultural Conference. F.R.I., Dehradun. 1961, 546-553.
8. Kaur A, Saxena V. Evaluation of multilocational clonal trials of *Eucalyptus* tereticornis in Haryana. *In:* Bagchi, S. K.; Varghese, M. and Siddappa. *Eds.* Recent *Eucalyptus* Research in India. Institute of Forest Genetics and Tree Breeding, Coimbatore, 2002, 1- 8.
9. Krishnakumar N, Sivakumar V, Anandlaxmi R. Eucalyptus improvement in southern India. In:

Eucalyptus in India. ENVIS Publication, FRI, Dehradun, 2014.
10. Kulkarni HD. Pulp and Paper Industry Raw Material-Global Scenario: ITC Plantation - A case Study. ITC Ltd., Bhadrachalam, Sarapaka-507128, 2010.
11. Kulkarni HD. Industrial agroforestry: An ITC initiative. Indian Farming. 2014; 63(11):42-44.
12. Lal P, Dogra AS, Sharma SC, Chahal GBS. Evaluation of different clones of *Eucalyptus* in Punjab. Indian Forester. 2006; 132(11):1383-1390.
13. Laxmikanth DM. Selection of *Eucalyptus* tereticornis and *Eucalyptus* grandis clones for high cellulose and low lignin and establishment of *in vitro* clone bank. In: Bagchi, S. K.; Varghese, M. and Siddappa. *Eds*. Recent *Eucalyptus* Research in India. Institute of Forest Genetics and Tree Breeding, Coimbatore, 2002, 183-188.
14. Luna RK, Singh B. Estimates of genetic variability and correlation in *Eucalyptus hybrid* progeny for early selection. Indian Forester. 2009; 135(2):147-160.
15. Mahajan S, Singh SV, Rao RV. Evaluation of *Eucalyptus hybrid* clones with respect to pulping and paper making properties. Indian Forester. 2000; 126(3):274-278.
16. Resquin F, Barrichelo LEG, Junior FGS, Brito JO, Sansigolo CA. Wood quality for kraft pulping of *Eucalyptus.* Scientia Forestalis. 2006; 72:57-66.
17. Venkatesh CS, Kedharnath S. Genetic improvement of *Eucalyptus* in India. Silvae Genetica. 1965; 14:171-176.
18. Vennila S, Parthiban KT, Seenivasan R, Saravanan V, Anbu PV, Kanna SU *et al.* Pulpwood characterization and screening short rotation *Eucalyptus* clones. Indian Journal of Ecology. 2011; 38:84-90.
19. www.celso-foelkel.com.br, cited in Rana V, Joshi G, Singh SP, Gupta PK. Eucalypts in Pulp and Paper Industry. In: Eucalyptus in India. ENVIS Publication, FRI, Dehradun, 2014.