Performance of *Eucalyptus* clones in Trans-Ganga region of Uttar Pradesh, India

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ABSTRACT : Present study was carried out to assess the growth and performance of *Eucalyptus* clones in Trans-Ganga region of district Prayagraj in Eastern Uttar Pradesh. A clonal trial was established in 2016 with 19 clones along with a control to assess their site-specific suitability. Their performances (height, girth at breast height (GBH), basal area and volume of trees/ha) were evaluated annually up to three years. Variation in height and GBH among 19 clones of *Eucalyptus* was noticed. The highest increment in GBH was recorded in clone P-13 (33.80 cm), followed by P-23 (33.43 cm), P-32 (33.27 cm), 526 (32.68 cm), IFGTB-4 (32.10 cm), 3018 (30.53 cm) and P-50 (29.60 cm), whereas the lowest in P-66 (22.50 cm) and control (20.38 cm). Maximum height was recorded in 3018 (12.55 m), followed by P-32 (12.29 m), P-23 (11.89 m) and P-13 (11.77 m) and minimum in clone 413 (9.99 m), 288 (9.95 m) and 2136 (9.28 m). Similarly, the basal area of P-13, P-23, P-32, 526 and IFGTB-4 was found to be encouraging. Conclusively, the clones P-32, P-13, P-23, 526, 3018, IFGTB-4 and P-50 were found promising for large scale plantation in Trans-Ganga region of Eastern Uttar Pradesh.

Key words: Agroforestry, *Eucalyptus camaldulensis*, growth attributes, performance and Prayagraj.

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1. INTRODUCTION

Eucalyptus, a member of family Myrtaceae, is one of the most widely cultivated forest trees (over 22 m ha) in the world (Nichols *et al.,* 2010). It is highly demanded in plywood and veneer industries. It can adapt a varied range of edaphic and climatic conditions (Goor and Barney, 1968) and its cultivation is considered an eco-friendly approach to cope up with the salinization of lands. Among five important trees outside forests in the state of Uttar Pradesh, the relative abundance of *Eucalyptus* in rural area is 15.86% and in urban area, 8.87% (FSI, 2019). It flourishes from coastal areas to areas situated at an altitude of 2000 m, tropical to warm temperate climate, and in area where rainfall ranges from 400 to 4000 mm (Tewari, 1992). In India, the majority of *Eucalyptus* plantations on government, forest, farm lands, community lands and along road/rail/canal strips are of seed origin. *Eucalyptus*, one of few trees due to its astonishing growth characteristics, is capable of reducing wide gap between demand and production of wood in shortest possible time (Chandra and Yadava, 1986). India is one of the largest *Eucalyptus* growing countries with a total area of 1.36 m ha in 1999 (FSI, 1999), which has increased to around 8 m ha in 2010 (Aregowda *et al.,* 2010). At present, area under agroforestry in India is estimated as 25.32 m ha or 8.2% of total geographical area of the country. A total of 53.32 Mha, representing about 17.57% of the total reported geographical area of India, could potentially be under agroforestry in the near future, thus making agroforestry a major land-use activity, after agriculture and forestry (Dhyani *et al*., 2013).

More than 65 *Eucalyptus* species and various provenances were tried to meet the various wood based demands of the country (Kulkarni, 2008). It produces heaviest, hardest and most durable wood, which makes this genus the most valuable source of hardwood in the world. *Eucalyptus* hybrids have been widely planted in India owing to its adaptability in different eco-climatic zones (Arya *et al.,* 2009). According to Vijayaraghavan and Sivakumar (2017), *Eucalyptus hybrid* and *Eucalyptus tereticornis* are the two most widely planted species in India. Many species can tolerate flooding or swamp lands and are given vernacular names e.g. flooded gum (*Eucalyptus grandis*), swamp gums (*Eucalyptus camphora* and *Eucalyptus ovata*), river red gum (*Eucalyptus camaldulensis*) and swamp mahogany (*Eucalyptus robusta*). The productivity of *Eucalyptus* varies from country to country with changing climatic, edaphic and topographic conditions. In Congo, Brazil and Papua New Guinea, clonal plantations of *Eucalyptus* have produced 80-90 m^3/ha/year (Ugalde and Perez, 2001) whereas in Indian conditions, it ranged between 6-10 m^3/ha/year in seed rooted plantations (Lal, 1993) to 20-23 m^3/ha/year in *rainfed* conditions, and 50 m^3/ha/year in clonal based managed farm plantations (Lal, 2001; Kulkarni, 2002). Sometime, it reaches to 100 t/ha in pulp wood plantation (Kulkarni, 2014).

In India, *Eucalyptus* is one of the most prime species in agroforestry and farmers are mostly diverting towards

clonal planting material for more returns in short rotation. In Uttar Pradesh, agroforestry practices vary according to the agro-climatic zones and socio-economic status of the farmers, tree diversity, existing cropping pattern and availability of irrigation water. The Gangetic Plain at the centre is large, as it covers nearly two-third area of the state. In Eastern Gangetic Plain region of Uttar Pradesh, *Eucalyptus* is in improving stage for adoption at large level and choice of suitable clones is still a big challenge. Thus, the study was conducted to assess suitable *Eucalyptus* clones for Trans-Ganga region of Prayagraj district of Eastern Uttar Pradesh for identification of suitable planting material to be adopted in agroforestry.

2. MATERIALS AND METHODS

The district Prayagraj is located between 24° 47' to 25° 47' N and 81° 19' to 82° 21' E at 102 m above mean sea level. It covers an area of 5246 km^2. The district lies in the southern part of the state in the Gangetic plain and adjoining Vindhyan Plateau of India. The district may be divided into three distinct physical parts as the Trans-Ganga or the Gangapar Plain, the Doab and Trans-Yamuna or the Yamunapar tract which are formed by the Ganga and its tributary. Trans-Ganga tract comprises of poor sandy soil (full of kankar) with stretches of sodic lands. The whole Trans-Ganga tract and the greater portion of Doab are composed of gangetic alluvium.

The average annual temperature is 25.7 °C and the annual rainfall is 981 mm. The soil of the site was sandy loam and its physico-chemical characteristics are: pH: 7.2–7.6, EC: 0.65–0.71 dS/m, organic carbon: 0.65-1.20% and N, P and K: 198.0-220.2, 18.2-24.5 and 235.5-248.2 kg/ha, respectively. An experimental trial was established in the year 2016 in Trans-Ganga tract in Soraon block, village Padilla of Prayagraj district. The trial was conducted under completely randomized block design with three replications and 3 × 2 m spacing for 19 commercial clones of Pragati Biotech, Punjab (413, 07, 526, IFGTB-4, K-25, 288, 2013, 2023, 2070, 2136, 3018, 2031, P-13, P-14, P-23, P-32, P-45, P-50 and P-66) of 3 eucalyptus species (*E. hybrid, E. tereticornis* and *E. camaldulensis*) along with a control (Table 1). The mixture of 100 g of NPK (3:2:1) fertilizer and FYM (1 kg/plant) were applied at onset of monsoon during planting to assist establishment of growth. The irrigation was also done twice a month normally and in hot summers once in a week. The annual increment of each clone was calculated using growth parameters (girth at breast height (GBH) and height) for consecutive three years. The basal area in m^2 (BA = 0.00007854 × DBH in cm) and volume of trees in m^3 ($V = \pi r^2 \times h$) / tree (r and h in m), (1667 trees/ha in 3 × 2 m spacing) were also calculated (Larsen, 1999). The data was analysed statistically by standard ANOVA technique using RBD and t-test. The statistical analysis was done using OPSTAT prepared by Statistical Software Package for Agricultural Research Workers of CCS HAU, Hisar, Haryana (Sheoran *et al*., 1998).

3. RESULTS AND DISCUSSION

The GBH varied from 22.50 to 33.80 cm with an overall mean of 28.09 cm. Maximum GBH was attained by clone P-13 and found comparable with P-23, P-32, 526, IFGTB-4, 3018 and P-50. The significant variation among clones for mean increment in height was recorded which varied from 9.28 to 12.29 m. The clones P-32, P-23, P-13, 526, 2013, IFGTB-4, P-45, 2023 and P-50 showed higher tree height than other clones. Clones P-13, P-23, P-32, 526 and IFGTB-4 recorded higher basal area. The volume of trees/ha (stand of 1667 trees/ha) were encouraging for P-32, P-13, P-23, 526, 3018, IFGTB-4 and P-50. This variation might be due to genetic factor, since all these clones were grown in a small piece of land having similar environmental condition.

Table 1. Details of *Eucalyptus* clones.

S. No.	Clone No	Species name
1.	P13	*E. camaldulensis*
2.	2136	*E. camaldulensis*
3.	P50	*E. camaldulensis*
4.	P23	*E. camaldulensis*
5.	526	*E. camaldulensis*
6.	P66	*E. camaldulensis*
7.	2070	*E. camaldulensis*
8.	288	*E. tereticornis*
9.	2023	*E. camaldulensis*
10.	P32	*E. camaldulensis*
11.	413	*E. camaldulensis*
12.	P14	*E. camaldulensis*
13.	3018	*E. hybrid*
14.	K25	*E. camaldulensis*
15.	2021	*E. camaldulensis*
16.	07	*E. tereticornis*
17.	P45	*E. camaldulensis*
18.	2013	*E. camaldulensis*
19.	IFGTB- 4	*E. camaldulensis*

Such genetic based improvement would be ideal for selection of superior genotypes for further multiplication and afforestation programme in similar environmental condition. Such result is also recorded by several researchers in different *Eucalyptus* species. Lal *et al.* (1997) reported that clone number 6 showed better performance in terms of height at seven years of age among studied 20 clones of *Eucalyptus*. At four years of age, clone 2070 of *Eucalyptus* among 36 clones showed best performance in terms of mean height (Lal *et al.*, 2006). Similarly, Kumar *et al.* (2010) reported significant variation among clones of *E. tereticornis* for DBH at the age of 5.5 years, whereas Dhillon and Singh (2010) also found difference in diameter growth among clones of *E. tereticornis* at the age of 3.5 years. Luna and Singh (2009) also studied clonal variation for growth parameters among 12 clones of *Eucalyptus* at Ludhiana. Such kind of variation would be helpful in selection of superior clones for multiplication and plantation purposes to obtain higher biomass and economic returns. Lal *et al.* (2006) identified best clones out of 36 *viz*., 2070, 285, 316, 288, 498, 286 and 2045 for ecological conditions in Punjab. In South Gujarat, clonal variation for growth parameters such as DBH, mid-diameter, height, form quotient and volume was recorded among 20 clones of *Eucalyptus* (Behera *et al*., 2016). Gangwar *et al.* (2015) identified clone AP10 of *Eucalyptus* as best clone among studied ones. Plantation companies and other organizations have identified few clones suitable for planting. It is common to come across hundreds of ha area planted with a single clone. The widespread damage due to gall incidence caused by *Leptoceyba invasa* (Aregowda *et al.,* 2010), especially in clonal nurseries and plantations has made planters to realize the necessity of sufficient genetic diversity in planting material (Vijayaraghavan and Sivakumar, 2017). The clonal material repeatability increased over years consistent with previous reports on heritability for *Eucalyptus* species (Osorio *et al*., 2001).

Table 2. Mean increment in height (m) and GBH (cm) of *Eucalyptus* clones.

S.No.	Clones	Mean increment in height (m)			Mean increment in GBH (cm)		
		Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
1.	P13	2.94	5.93	11.77	5.93	20.65	33.80
2.	2136	3.01	6.23	9.28	6.23	13.80	23.62
3.	P50	3.46	7.35	10.66	7.35	20.35	29.60
4.	P23	2.72	6.55	11.89	6.55	22.78	33.43
5.	526	3.12	7.48	11.73	7.48	21.83	32.68
6.	P66	2.74	3.62	10.38	3.62	13.47	22.50
7.	2070	2.32	4.77	10.38	4.77	15.73	26.53
8.	288	2.64	5.67	9.95	5.67	16.60	27.15
9.	2023	3.26	6.90	10.70	6.90	18.37	28.02
10.	P32	3.24	7.42	12.29	7.41	21.50	33.27
11.	413	3.19	6.00	9.99	6.00	17.65	26.83
12.	P14	2.64	5.85	10.34	5.85	17.25	28.50
13.	3018	2.80	4.77	12.55	4.77	20.10	30.53
14.	K25	2.11	4.98	10.12	4.98	15.85	26.48
15.	2021	2.68	4.62	10.21	4.61	13.92	24.53
16.	07	2.37	4.90	10.32	4.90	13.48	25.73
17.	P45	2.75	5.15	10.80	5.15	16.82	28.28
18.	2013	3.11	5.90	11.12	5.90	18.13	27.87
19.	IFGTB- 4	1.80	3.77	11.02	3.77	16.67	32.10
20.	Control	2.10	3.30	7.92	3.30	10.38	20.38
	$LSD_{0.05}$	0.87	2.36	2.16	2.36	5.00	6.66
	S. Em. (±)	0.30	0.82	0.75	0.82	1.74	2.33

Table 3. Basal area and tree volume/ha after three years of planting.

S.No.	Clones	Height (m)	Girth (cm)	DBH (cm)	Basal area/ tree (m^2)	Volume/ tree (m^3)	Volume (m^3/ha)
1	P13	12.27	34.83	11.09	0.0097	0.118	197.46
2	2136	9.79	24.83	7.90	0.0049	0.048	80.07
3	P50	11.19	30.78	9.80	0.0075	0.084	140.64
4	P23	12.34	34.45	10.97	0.0094	0.117	194.28
5	526	12.21	33.73	10.74	0.0091	0.111	184.28
6	P66	10.81	23.65	7.53	0.0045	0.048	80.21
7	2070	10.78	27.5	8.75	0.0060	0.065	108.15
8	288	10.36	27.88	8.87	0.0062	0.064	106.83
9	2023	11.19	29.22	9.30	0.0068	0.076	126.74
10	P32	12.78	34.37	10.94	0.0094	0.120	200.28
11	413	10.50	27.75	8.83	0.0061	0.064	107.26
12	P14	10.77	29.6	9.42	0.0070	0.075	125.18
13	3018	12.97	31.4	10.00	0.0078	0.102	169.64
14	K25	10.54	27.45	8.74	0.0060	0.063	105.36
15	2021	10.66	25.43	8.09	0.0051	0.055	91.45
16	O7	10.74	26.48	8.43	0.0056	0.060	99.90
17	P45	11.22	29.12	9.27	0.0067	0.076	126.22
18	2013	11.56	28.92	9.21	0.0067	0.077	128.26
19	IFGTB4	11.38	32.97	10.49	0.0087	0.098	164.10
20	Control	8.29	21.22	6.75	0.0036	0.030	49.52
	Mean	11.12	29.08	9.26	0.007	0.078	129.29
	SD	1.08	3.79	1.21	0.002	0.026	43.19

4. CONCLUSION

The selection of promising clones for site-specific conditions is a challenging task, as yield and quality of wood production is totally dependent on adequate planting material. In view of this fact, the present study concluded that all 19 clones with control significantly varied for tree height and GBH. The clones such as P-13 and P-23 performed very well in respect to GBH of clones. Overall, the clones P-32, P-13, P-23, 526, 3018, IFGTB-4 and P-50 with highest tree volume may be recommended for large scale plantation programme in Trans-Ganga region of Eastern Uttar Pradesh.

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