Promising Eucalyptus Clones for Vindhyan Region of Uttar Pradesh

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Received:- 05 July 2023/ Revised:- 15 July 2023/ Accepted:- 24 July 2023/ Published: 31-07-2023

Abstract**—** *As a short rotation and fast growing nature, Eucalyptus is widely preferred by farmers for pulp paper and plywood industries as well as in local market for poles. In eastern Uttar Pradesh, eucalypts are in improving stage for adoption at larger level and choice of suitable clones in plantations is still a big challenge for them. Thus, the main objective of this study was to assess the growth performance of Eucalyptus clones in Vindhyan region of Mirzapur district for identification of promising clones. An experimental trial was established in the year 2016 with 19 commercial clones at spacing of 2x3 meter in randomized block design in Mirzapur. The annual increment of each clone was calculated using all the growth parameters (girth at breast height; gbh and height) for consecutive five years. The highest value of increment in gbh belonged to clones P-32 (53.88 cm) followed by 07 (51.96 cm), P-14 (50.40 cm), 288 (48.24 cm), P-23 (46.89 cm), P-50 (45.79 cm), and P-13 (44.99 cm) after five year of planting. The clones with good annual increment in height were 07 (17.50 m) followed by P-32 (17.33 m). On the basis of growth parameters, viz. height, girth at breast height, basal area and tree volume, clone P-32, 07, P-14, 288, P-23, P-50 and P-13 were promising over others. (Fig.1). All superior clones belonged to species E. camaldulensis except 288 and 07 which were of E. tereticornis. The results of the analysis of variance (ANOVA) for mean height and girth increments showed high levels of significance.*

Keywords— Eucalyptus, pulp paper, plywood industries, E. tereticornis, E. camaldulensis.

I. INTRODUCTION

The early introduction of *E. camaldulensis* and *E. tereticornis* to India was from southern temperate localities in Australia rather than the northern tropical regions where the climatic conditions closely resemble the areas available in India because of the inaccessibility and difficulties in collecting seeds (Boland *et al*. 1981). Therefore, there is an urgent need for improvement in production of forest resources to meet the needs of fuel-wood, timber and wood production on a sustainable basis and increase biomass yield from farm forestry plantations (Patil *et al*. 2012, Srivastav *et al.* 2018). India has ~10% of the world's Eucalyptus plantation. As per the Food & Agriculture Organisation (FAO) Report (FP/48/E) 2014, around 93% of industrial wood requirement in the country is met out of agro/farm forestry plantations (~70% is Eucalyptus). In eastern Gangetic Plain region of Uttar Pradesh state of India, Eucalypts are in improving stage for adoption at larger level and choice of suitable clones in plantations is still a big challenge. Large scale Eucalyptus plantations have been raised on forest & farm lands, community lands and road / rail / canal strips in India. These plantations have created very useful resource for timber, poles, pulpwood and fuel-wood. However, most of these past plantations had very large genetic variation, low productivity ranging from 6 to 10 m3.ha-1.yr-1 and poor returns because inferior seed used for raising most of the target oriented plantations (Lal, 1993). As a short rotation and fast growing nature, Eucalyptus is widely preferred by farmers for pulp and paper industries as well as in local market for pole (Behera, 2016). In eastern part of Uttar Pradesh state of India, Eucalypts are in improving stage for adoption at larger level and choice of suitable clones in plantations is still a big challenge for them. Thus, the main objective of this study was to assess the growth performance of Eucalyptus clones in Vindhyan region of eastern Uttar Pradesh in Mirzapur district for identification of promising planting material.

II. MATERIAL AND METHODS

Study area - Mirzapur district is bounded on the north by Bhadohi and Varanasi districts, on the east by Chandauli district, on the south by Sonbhadra district and on the northwest by Prayagraj in eastern UP. The district occupies an area of 4521 km^2. Mirzapur city is the district headquarters. Mirzapur district is a part of Mirzapur division (Fig.1). It has an average sea elevation of 80 m (265 feet). The District of Mirzapur lies between the parallels of 23.52 & 25.32 North latitude and 82.7 and 83.33 East longitude. On the north and north-east it is bounded by the Varanasi district; on the south bounded by Sonbhadra district; on the north-west by Prayagraj district. The shape to the north and west is totally regular. In no direction, except for

about 13 km in the north-east where the Ganges separates the Tehsil of Chunar from the district of Varanasi, has Mirzapur a natural frontier. According to the Central Statistical Organisation, the district of Mirzapur had an area of 4521 km^2 (Censusindia.gov.in, 2011).

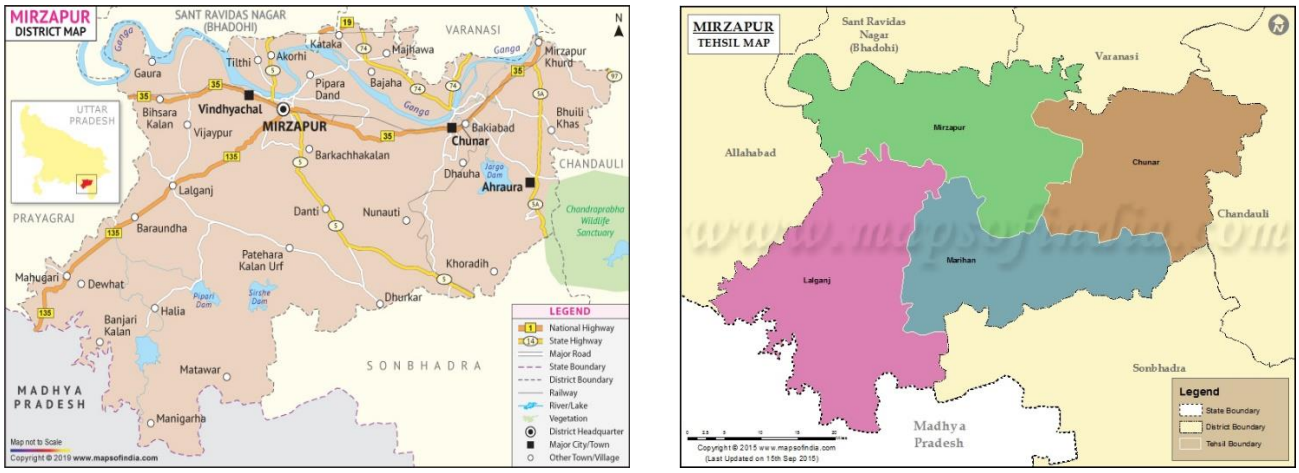

FIGURE 1: Map of district Mirzapur

III. ESTABLISHMENT OF EXPERIMENTAL TRIAL

An experimental trial was established in year 2016 with 19 commercial clones at spacing of 2x3 meter in village Nikarika. It is a small Village/hamlet in Raigarh Block/tehsil of Mirzapur District of Uttar Pradesh State and located at a distance of 55 km from district head quarter. A total of 20 treatments with 19 clones and one control in randomized block design on field bunds in three replications were taken under study. The soil analysis was done for pH, EC, organic carbon and NPK contents using standard procedures (Jackson, 1985). The mixture of 100 g of NPK (3:2:1) fertilizer and FYM (1.0 kg per 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 all the growth parameters (girth at breast height; gbh and height) for consecutive 4 years. The basal area in m^2 (BA =0.00007854 x DBH in cm) and volume of trees in cum ($V= \pi r^2 x h$) / tree (r and h in m), (1667 trees / ha in 3x2 spacing) were also calculated (Larsen, 1999). The annual increment of each clone was calculated using all the growth parameters for girth at breast height and height after one year of planting to assess early growth performance of clones. The data were statistically analysed by standard ANOVA techniques (XLSTAT). The statistical analysis was done by data analysis tool package of OPSTAT prepared by Statistical Software Package for Agricultural Research Workers. CCS HAU, Hisar, Haryana (Sheoran *et al*. 1998). The details of clones were as following:

THE DETAILS OF CLONES AND SPECIES NAME

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.	04	*E. camaldulensis*

IV. RESULTS AND DISCUSSION

The results of growth performance of these clones were recorded for annual increments of height (m) and girth at breast height; gbh (cm) for five years and were depicted in Table 1& 2 and Fig. 2 & 3. The site was with red acidic soil and analysis indicated pH 6.10, EC 0.42 mm/cm, organic carbon 0.21 %, Nitrogen 182.44 kg/ha, Phosphorus 11.23 kg/ha and Potassium 220.38 kg/ha. The highest value of gbh belonged to clones P-32(53.88 cm) followed by 07 (51.96 cm), P-14 (50.40 cm), 288 (48.24 cm), P-23 (46.89 cm), P-50 (45.79 cm), and P-13 (44.99 cm) after five year of planting. The lowest values belonged to clone 2013 and P-66 with 38.58 and 40.82 cm respectively. The clones with good increment in height were 07 (17.50 m) followed by P-32 (17.33 m). The basal area and tree volume were also analysed.On the basis of growth parameters, *viz.* height, girth at breast height, basal area and tree volume, clones P-32, 07, P-14, 288, P-23, P-50 and P-13 performed superior over all other treatments in Mirzapur district (Table 3, Fig. 4, 5 & 6). All superior clones belonged to species *E. camaldulensis* except 288 and 07 which were of *E. tereticornis.* The results of the analysis of variance (ANOVA) for mean height and girth increments showed high levels of significance. The results of growth performance indicated that all clones gave superior results for growth indicators as compared to control. The performance of control was inferior for girth increments as compared to clone series. The remaining clones had different ranks of gbh and height increments as compared to the control.

TABLE 1
ANNUAL INCREMENT IN HEIGHT (M) IN MIRZAPUR IN 4 YRS

S. No.	Clone	Year 1	Year 2	Year 3	Year 4
1	P66	2.24	2.46	4.06	3.11
2	K25	2.90	1.69	5.29	4.24
3	07	2.79	4.40	8.14	1.87
4	P32	3.84	5.11	6.77	2.16
5	04	3.47	5.81	5.67	2.99
6	3021	2.64	4.84	3.41	6.28
7	2070	2.83	3.43	5.39	5.30
8	413	2.19	2.75	6.08	4.81
9	2023	2.19	2.40	2.87	7.52
10	526	2.12	4.11	3.61	4.82
11	2013	2.29	1.60	5.69	3.16
12	Control	1.27	1.08	1.63	5.44
13	P23	2.42	2.14	6.71	3.59
14	288	3.06	2.40	6.40	1.88
15	3018	3.20	2.82	4.64	3.35
16	2136	2.39	1.61	5.65	3.94
17	P14	2.33	2.69	5.29	4.60
18	P13	3.50	2.86	4.04	2.90
19	P50	2.70	2.92	4.27	3.34
20	P45	2.69	1.95	4.40	3.27
	C.D.	0.09	0.65	1.33	2.989
	SE(m)	0.03	0.23	0.46	1.040
	SE(d)	0.04	0.32	0.66	1.471
	C.V.	13.34	13.07	13.76	16.567

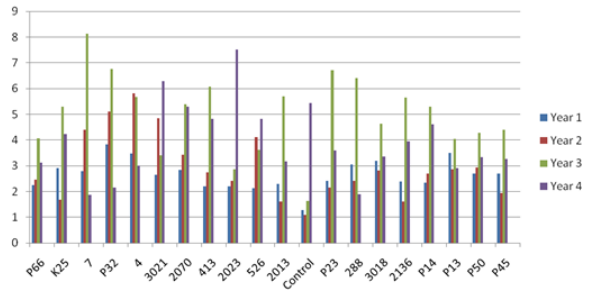

FIGURE 2: Annual increment in height (m) in 4 years

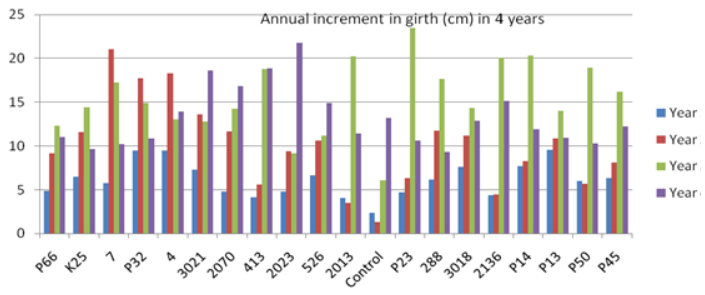

FIGURE 3. Annual increment in girth (cm) in 4 years

TABLE 2
ANNUAL INCREMENT IN GIRTH (CM) IN 4 YEARS

S. No.	Clones	Year 1	Year 2	Year 3	Year 4
1	P66	4.86	9.17	12.33	11.00
2	K25	6.50	11.57	14.43	9.64
3	07	5.72	21.07	17.23	10.20
4	P32	9.46	17.73	14.88	10.89
5	04	9.46	18.33	13.02	13.96
6	3021	7.33	13.57	12.79	18.64
7	2070	4.82	11.67	14.23	16.83
8	413	4.16	5.57	18.79	18.89
9	2023	4.80	9.37	9.16	21.80
10	526	6.62	10.60	11.19	14.91
11	2013	4.07	3.53	20.21	11.40
12	Control	2.40	1.30	6.12	13.17
13	P23	4.70	6.33	23.49	10.64
14	288	6.16	11.77	17.64	9.29
15	3018	7.59	11.17	14.36	12.89
16	2136	4.41	4.50	20.10	15.14
17	P14	7.72	8.23	20.31	11.94
18	P13	9.58	10.83	14.02	10.94
19	P50	5.99	5.67	18.91	10.29
20	P45	6.36	8.07	16.17	12.23
	C.D.	0.33	2.65	4.97	7.57
	SE(m)	0.12	0.92	1.73	2.64
	SE(d)	0.16	1.30	2.45	3.73
	C.V.	21.20	22.58	17.87	14.19

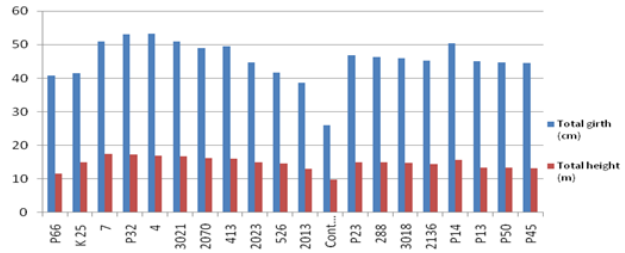

FIGURE 4: Total girth (cm) and height (m) after 4 years

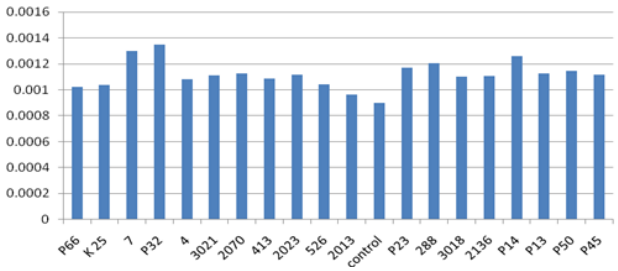

FIGURE 5: Basal area of clonal tree (m^2)

TABLE 3
GROWTH PERFORMANCE FOR BASAL AREA AND TREE VOLUME IN 4 YEAR

S.N.	Growth performance of clones after 4 years				
	Clone	Total girth including initial girth (cm)	Total height including initial height (m)	Basal Area/tree (m^2)	Volume/tree (m^3)
1	P66	40.82	11.52	0.001021	0.541539
2	K 25	41.44	14.92	0.001037	0.566591
3	07	50.96	17.50	0.001300	1.116909
4	P32	53.08	17.33	0.001348	1.245355
5	04	53.22	16.94	0.001081	0.642783
6	3021	50.93	16.78	0.001109	0.693591
7	2070	48.99	16.25	0.001125	0.725034
8	413	49.48	15.94	0.001088	0.654454
9	2023	44.67	14.86	0.001117	0.709673
10	526	41.71	14.58	0.001043	0.577738
11	2013	38.58	12.90	0.000965	0.457190
12	Control	26.03	9.85	0.000901	0.372394
13	P23	46.89	14.93	0.001173	0.820826
14	288	46.24	14.97	0.001207	0.893783
15	3018	45.86	14.76	0.001102	0.680995
16	2136	45.28	14.33	0.001108	0.691247
17	P14	50.40	15.70	0.001261	1.019300
18	P13	44.99	13.36	0.001125	0.725034
19	P50	44.79	13.26	0.001145	0.764403
20	P45	44.54	13.22	0.001114	0.703495
	C.D.	7.38	2.10	-	-
	SE(m)	2.57	0.73	-	-
	SE(d)	3.63	1.03	-	-
	C.V.	9.84	8.60	-	-

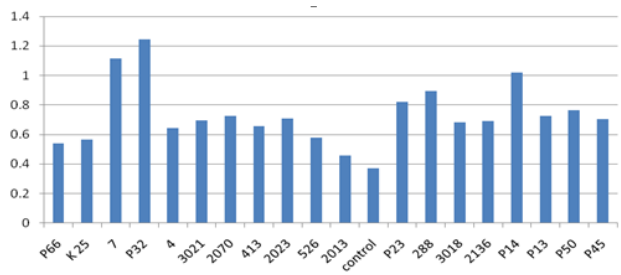

FIGURE 6: Volume of clonal tree (m^3)

Luna and Singh (2009) studied the growth performance of 12 clones of Eucalyptus at Ludhiana. Clones 413 and 2070 recorded significantly higher height growth as compared to other clones. In south Gujrat, clonal variation for growth parameters such as DBH, mid- diameter, height, form quotient and volume was significantly different among 20 clones of Eucalyptus and DBH varied between 11.47 and 16.07 cm with an overall mean of 13.28 cm (Bahera, 2016). Kumar *et al* (2006) evaluated different clones of *Eucalyptus tereticornis* for different growth characters including tree height. Gangwar *et al.* (2015) identified Clone AP10 of Eucalyptus as the best clone among the studied ones based on height. It is also established that *E. camaldulensis* as a pure species is adapted to low-to intermediate rainfall environment with a dry season of up to 8 months (Eldridge *et al.* 1993).

Lal *et al.* (2005) evaluated growth performance of 36 clones of Eucalyptus and clone 2070 performed best with maximum mean height of 16.29 m as compared to other clones at the age of 6 years. The variation among clones in growth parameter may be due to genetic make-up and interactions with the environmental factors. Similarly, Kumar *et al.* (2006) 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. Lal *et al* (2006) identified best clones out of 36 *viz.*, clone 2070, 285, 316, 288, 498, 286 and 2045 for Punjab ecological condition.

Wei Zhongmian *et al.*, (2009) evaluated the growth comparison of eight year old Eucalyptus clones revealed that, Eucalyptus clones showed high growth rate during the first three years. There were significant differences amongst the 3 Eucalyptus clones in plant height, diameter and volume growth. The significant G x E interaction observed among clones/seed origin on test site in the present study indicates that clones have to be tested in target environments before deploying in plantations (Oballa *et al*., 2005).

Among the 22 clones of *Eucalyptus camaldulensis* planted in the clonal trial at Badami (Karnataka) clones Clone C- 10,19,188 are performing better than all other clone planted in that particular location having same soil property (sandy loam) and climatic conditions (Vijayaraghavan et al., 2015). The fact that most clones outperformed the provenance seed lots at comparatively waterlogged condition (Karaikkal); whereas some clones were inferior to the best provenance seed lot demonstrates that clonal selections should not be transferred to contrasting environments without thorough testing (Vijayaraghavan et al., 2016). The clones of species *E. camaldulensis* performed superior over other clones/species. Similarly, significant differences in different *Eucalyptus* species have been reported by various workers.

The variation among clones in growth parameter may be due to genetic make-up and interactions with the environmental factors. Similarly, Dhillon and Singh (2010) also found difference in diameter growth among clones of *E. tereticornis* at the age of 3.5 years. Lal *et al* (2006) identified best clones out of 36 *viz*., clone 2070, 285, 316, 288, 498, 286 and 2045 for Punjab ecological condition. Red Gum (*Eucalyptus camaldulensis* L.) is renowned globally for its fast growth, high levels of drought tolerance and adaptability to diverse climatic conditions and soils, which makes it popular among eucalypt tree growers (Bindumadhava *et al*. 2011). The results of study confirm that clones of *E. camaldulensis* are well adaptable in Vindhyan region of Mirzapur district of Eastern Uttar Pradesh in India.

V. CONCLUSION

It is clear from the study that selection of clones for a particular site is very important to get maximum productivity of clonal eucalypts plantations in and around Eastern Uttar Pradesh. In addition, this study demonstrated that there would be clear benefits, with respect to productivity of a large eucalypt plantation to pursuing site-specific selection and deployment strategies for the high productive clones. Although implementing such a strategy could require significant investments in field trials, for larger growers with plantations spread across site types, the benefits with respect to increased clonal plantation with site specific clones would be more beneficial. Thus, suitable clones of eucalypts may improve agroforestry in the region of eastern UP. The identified commercial clones of Eucalypts may open a new path for stakeholders of the region for more adoption of species in agroforestry models with better returns after shorter duration of time. Therefore, clonal plantations of Eucalyptus under agro-forestry system should be encouraged and integrated with planned development of wood based industries through innovative policy changes.

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