**Evaluation of Eucalyptus Clones in Eastern Gangetic Plains of Uttar Pradesh , India**

***Abstract***

Eucalyptus is among the most widely cultivated forest trees in the world over 22 million hectares (ha) .It provides major raw material for the pulp , plywood and paper industries in India, so it is imperative that planting stock of high genetic quality be used to increase the yield from plantations. In India, Eucalypts are in improving stage for adoption at larger level and choice of suitable clones is still a big challenge in eastern part of Uttar Pradesh. To assess the suitable clones of Eucalyptus for this region, an experimental trial was established under statistical design of Randomised Block Design for 13 clones (IFGTB 1,2,3,4,5,6,7,8,9,10, FRI-100,104,124) of 02 eucalyptus species (*E. tereticornis* and *E. camaldulensis)* .The soil analysis indicated pH 9.3, EC 0.89 mm/cm, organic carbon 0.21 %, Nitrogen 47.3 kg/ha, Phosphorus 11.3 kg/ha and Potassium 184.8 kg/ha. The highest value of annual increment in gbh belonged to clones IFGTB 6 (5.18 cm) followed by IFGTB 8 (5.12 cm), IFGTB 2 (4.74 cm), IFGTB 5(4.36 cm) and IFGTB 10 (4.02cm) amongst IFGTB series whereas in FRI clones, clone FRI 100 performed superior with 3.03 cm increment in girth after one year of planting. The lowest values belonged to clone IFGTB 9 and DDN 124 with 2.44 cm and 2.49, respectively. The clones with good annual increment in height were IFGTB 2 (3.85 m) followed by IFGTB 6 (3.80 m), IFGTB 10 (3.77 m) ,IFGTB 8 (3.55 m) and IFGTB 5 ( 3.30 m) in IFGTB series whereas in FRI series, FRI 100 (2.70 m) performed superior over other two clones. The survival of plants was in range of 66-100%. The clones of species *E. camaldulensis* in IFGTB series performed better over other clones/species. The evaluation of Eucalypt clones will be helpful for identification of promising clones for the specific region, thus, planting stock of desired clones may be raised for their further cultivation in field. The expansion of plantations of Eucalyptus in agro forestry will be helpful in reducing pressure of forests, increasing trees outside forests and upgrading the economic level of farmers.

**Introduction**

Eucalyptus is among the most widely cultivated forest trees in the world over 22 million hectares [1]. It is one of few trees which due to its astonishing growth characteristics are capable of reducing wide gap between demand and production of wood in shortest possible time [17]. In India, this plant provides maximum raw material for the pulp and paper industries, so it is imperative that planting stock of high genetic quality be used to increase the yield from plantations [2]. They contribute significantly to reduce the wide gap between demand and production of wood in the shortest possible time [3]. The species provide ample scope for genetic improvement due to wide geographic distribution and natural occurrence of variation. Existing forests in India cannot meet the demand for timber, firewood and wood based products on sustainable basis because of low growing stock, poor increments, inadequate financial and technological inputs, unbearable biotic pressures and serious degradation of forest resources [4]. The demand of wood from forest or commercial plantation for timber, fuel wood, pulp and paper production is increasing each year at an alarming rate. The clones are preferred for their fast growth with a short rotation, wide adaptability to site conditions, produce better quality wood and more uniform stands than most indigenous trees [5]. 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. [6, 17] 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). 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 [7, 17]. In India, Eucalyptus is one of the most prime species in Agro forestry and farmers are mostly diverting towards clonal planting material of this species for more returns in shorter rotation period. In the state of Uttar Pradesh in India, agroforestry practices vary according to the agroclimatic zones and socio-economic status of the farmers. Considering the tree diversity, existing cropping pattern, availability of irrigation water, soil, climate, rainfall and other agro-meteorological characteristics of the area, the state is divided into nine agro-climatic zones, viz. (i) Bhabhar and Tarai Zone, (ii) Bundelkhand Zone, (iii) Central Zone, (iv) Eastern Plain Zone, (v) Mid-Western Plain Zone, (vi) North Eastern Plain Zone, (vii) South Western Semi-Arid Zone, (viii) Vindhyan Zone and (ix) Western Plain Zone [8]. The Gangetic Plain region at the centre is large as it covers nearly two-thirds of the state. 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. Thus, the main objective of this study was to assess the early growth evaluation of Eucalyptus clones on salt affected sites of Gangetic plains of Eastern Uttar Pradesh in India for identification of suitable planting material. Therefore, the study results reveal information for identification of promising clones to be grown in Gangetic plain region of India.

**Material and Methods**

The district Pratapgarh in Gangetic plains of Eastern Uttar Pradesh, India forms a part of Allahabad Division and lies between the parallels of 25°34′ and 26°11′ north latitude and between the meridians of 81°19′ and 82°27′ east longitude extending for some 110 kilometres from west to east. It is bounded on the north by the district of Sultanpur, on the south by Allahabad, on the east by Jaunpur, on the west by Fatehpur and north-west by Raebareli. In the south-west the Ganges forms the boundary of the district for about 50 kilometres. Separating it from Fatehpur and Allahabad and in the extreme north-east, the Gomti forms the boundary for about 6 kilometres. The district has an area of 3,730 square km.The majority of the land is salt affected in the district. To assess the suitable clones of Eucalyptus for this region, an experimental trial was established under statistical design of randomized complete blocks with three replicates and 3 x 2 m spacing for 13 clones IFGTB 1,2,3,4,5,6,7,8,9,10, FRI-100,104,124 of 02 eucalyptus species (*E. tereticornis* and *E. camaldulensis)* along with control (locally available seedlings) for 14 treatments in Pratapgarh district of Eastern Uttar Pradesh in year 2017. The soil analysis was done for pH, EC, organic carbon and NPK contents using standard procedures. [9] 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).

**Results**

The results of early growth performance evaluation of these clones after one year of planting were carried out for mean annual measurements of total height, gbh and survival (Fig.1,2 & 3). The site was salt affected and soil analysis indicated pH 9.3, EC 0.89 mm/cm, organic carbon 0.21 %, Nitrogen 47.3 kg/ha , Phosphorus 11.3 kg/ha and Potassium 184.8 kg/ha. The highest value of annual increment in gbh belonged to clone IFGTB 6 (5.18 cm) followed by IFGTB 8 (5.12 cm),IFGTB 2 (4.74 cm), IFGTB 5 (4.36 cm) and IFGTB 10 (4.02 cm) amongst IFGTB series whereas in FRI clones, FRI 100 performed superior with 3.03 cm increment in girth after one year of planting. The lowest values belonged to clone IFGTB 9 and DDN 124 with 2.44 cm and 2.49, respectively. The clones with good annual increment in height were IFGTB 2 (3.85 m) followed by IFGTB 6 (3.80 m), IFGTB 10 (3.77 m) ,IFGTB 8 (3.55 m) and IFGTB 5 ( 3.30 m) in IFGTB series whereas in FRI series, FRI 100 (2.70 m) performed superior over other two clones. The survival of plants was in range of 66-100%.

The clones of species *E. camaldulensis* in IFGTB series performed better over other clones/species. The performance of control (local seed grown seedlings) was inferior for girth increments as compared to both clone series.The remaining clones had different ranks of gbh and height increments as compared to the control. The results of the analysis of variance (ANOVA) for annual mean increment in height and girth showed levels of significance (Table 1 &2). The clones of IFGTB series 2,6,8 & 10 and FRI 100 performed superior over other clones. The results of early growth performance indicated that out of thirteen clones, all clones gave superior results for growth indicators as compared to control.

**Discussion**

The clones of species *E. camaldulensis* performed superior over other clones/species. The IFGTB clones 2,6,8 & 10 and FRI -100 remarkably performed good in salt affected land of the selected site. The overall development of selected clonal plants was superior to locally seed grown plants. The survival of plants varied in different clones. The significant differences in different *Eucalyptus* species have been reported by various workers. Lal [10] conducted a study to assess the comparative growth performance of various Eucalyptus species. 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 [11]. The significant differences for growth attributes among seven species of *Eucalyptus* species were also studied. It is also established that *E. camaldulensis* as a pure species is adapted to low-to intermediate rainfall environments with a dry season of up to 8 months [12]. Several studies have reported the significant growth performance of Eucalyptus clones in the world. The results from these studies show that Eucalypts hybrid has similar or better growth than their parent and significant differences in growth between hybrid clones may be attributed to genetic constitution as well as environmental factors. For example, [13&14] observed significant differences for growth attributes among seven species of Eucalyptus clones. These differences in dbh between clones within a site may be attributed to genetic difference [15]. Survival in general is influenced by several factors, which include site management, especially the weeding frequency and the protection of the seedlings from pests and diseases, drought and seedling handling during planting period [16]. The identification of promising clones for the region will open a new path for farmers to adopt this species more widely in agro forestry. As per report of Forest Survey of India, 2017, the forest cover including tree cover is only 9.18 % in the state of Uttar Pradesh. To increase this tree cover part, adoption of agro forestry by farmers is the only viable option. Thus, suitable planting material of Eucalyptus will be a boon for local farmers for strengthening their economic level through agro forestry.

**Conclusion**

The results of study confirm that *E. camaldulensis* clones were better suited to growth at early stage in Gangetic plain region of Pratapgarh district of Uttar Pradesh state of India [17]. However, these were early growth results, with expected low juvenile mature correlations, and growth monitoring will continue in this trial series for confirm assessment of promising clones for the region. The assessment of performance of Eucalypt clones will be helpful for identification of promising clones for the specific region, thus, planting stock of desired clones may be raised for their further cultivation in field. The expansion of plantations of Eucalyptus in agro forestry will be helpful in reducing pressure of forests and increasing trees outside forests.

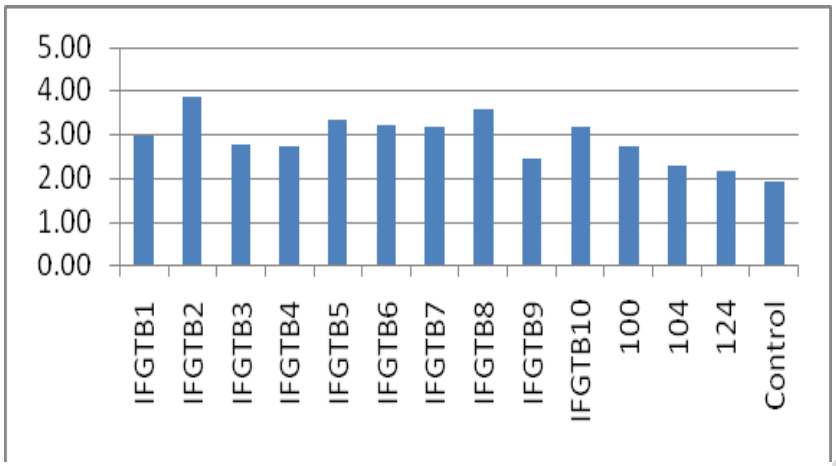


Fig. 1 Annual increment in height (m) after one year of planting

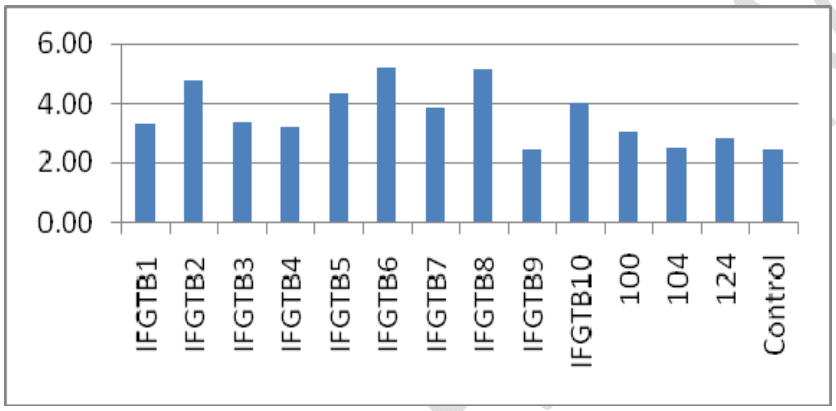


Fig.2 Annual increment in gbh (cm) after one year of planting

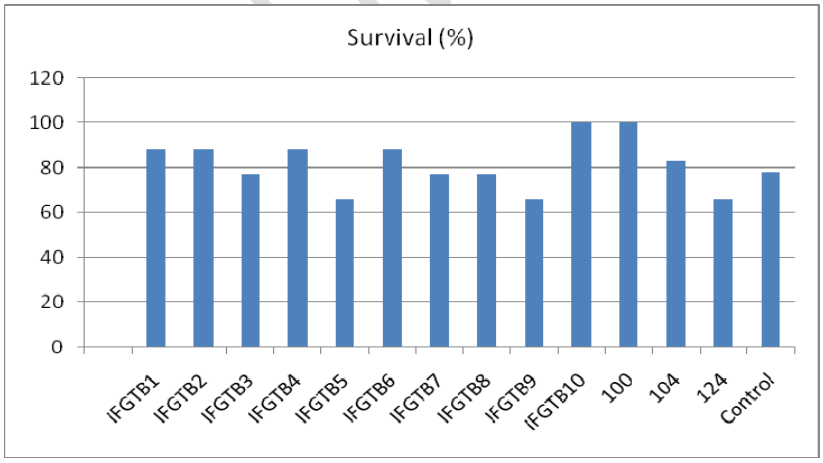


Fig.3 Survival (%) of clones after one year of planting

Table 1. Analysis of variance for annual increment in height (m)

| Source | D.F. | SS | MSS | Cal. F | TAB F(5%) | TAB F(1%) |
|---|---|---|---|---|---|---|
| Treatment | 13 | 11.83 | 0.91 | 4.69 | S | S |
| Replication | 2 | 1.00 | 0.50 | 2.57 | NS | NS |
| Error | 26 | | 0.19 | | | |
| TOTAL | 41 | 17.87 | | | | |
| #VALUE! | 0.25 | CD(5%)= | 0.74 | TAB. F(5%)= | 2.12 | |
| SE.d= | 0.36 | CD(1%)= | 1.00 | TAB. F(1%)= | 2.90 | |
| CV= | 15.37 | | | | | |

Table 2. Analysis of variance for annual increment in gbh (cm)

| Source | D.F. | SS | MSS | Cal. F | TAB F(5%) | TAB F(1%) |
|---|---|---|---|---|---|---|
| Treatment | 13 | 36.30 | 2.79 | 2.21 | S | NS |
| Replication | 2 | 0.13 | 0.06 | 0.05 | NS | NS |
| Error | 26 | 32.89 | 1.26 | | | |
| TOTAL | 41 | 69.31 | | | | |
| #VALUE! | 0.65 | CD(5%)= | | 1.89 | TAB. F(5%)= | 2.12 |
| SE.d= | 0.92 | CD(1%)= | | 2.55 | TAB. F(1%)= | 2.90 |
| CV= | 31.28 | | | | | |

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