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Research Article

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Suitability of Eucalyptus Clones in Eastern Gangetic Plains of Uttar Pradesh, India- A Case Study in the Raebareily District, India

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ABSTRACT
In India, Eucalyptus is one of the prime species in Agroforestry and farmers are mostly diverting towards clonal planting material of this species for more returns in a shorter rotation period. Eucalyptus is among the most widely cultivated forest trees in the world over 22 million hectares. Eucalyptus *hybrid* and *E. tereticornis* are the two most widely planted Eucalyptus trees in India. The area under agroforestry in India is estimated as 25.32 million ha (Mha), or 8.2 per cent of the total geographical area of the country. A total of 53.32 Mha, representing about 17.57 per cent of the total reported geographical area (TRGA) of India, could potentially be under agroforestry in the near future, thus making agroforestry a major land-use activity, after agriculture and forestry. In the recent past, clonal forestry had played a significant role in producing better production yield in a shorter time. It is also well established that the performance of Eucalyptus clones is superior over normal seed-borne plants. Therefore, there is an urgent need for improvement in the 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. Thus, the main objective of this study was to assess the growth performance of Eucalyptus clones in the Gangetic plains of Eastern Uttar Pradesh in the Raebareily district for the identification of suitable planting material. The trial was conducted under the statistical design of Complete Randomized Blocks with 3 replicates and 3 x 2 m spacing for all 19 clones of Pragati Biotech, Punjab (413,07,526, 04, K-25, 288, 2013, 2023, 2070, 2136, 3018, 2031, P-13, P-14, P-23, P-32, P-45, P-50, P-66) of 03 eucalyptus species (*E. hybrid*, *E. tereticornis and E. camaldulensis*) along with control for all 20 treatments in respective districts. Based on growth performance parameters such as height, girth, diameter, basal area and tree volume, overall clones- P-13, P-50, P-23, 526, P-32, 3018 and P-45 performed superior over other treatments in the Raebareily district. Here, all well-performing clones of the Punjab series belonged to *E. camaldulensis* only whereas 3018 is *E. hybrid.* This study has clearly shown that the selection of clones for a particular site is very important to get maximum productivity of clonal eucalypt plantations in and around Eastern Uttar Pradesh.
Keywords: Clonal Eucalyptus, suitability, growth attributes, agroforestry, promising clones.

INTRODUCTION

Many wood-based industries have started to raise large-scale *Eucalyptus* plantations as it provides a variety of uses such as timber, construction boles, firewood, honey, pulp, and paper. *Eucalyptus* can withstand salinity, drought and waterlogging conditions and also acts as recreational areas, windbreaks, shelterbelts etc. (Sandhu *et al.* 2020; Silva *et al.* 2014). Eucalyptus plantations can also improve degraded lands by stabilizing soils, improving soil nutrient status and increasing soil organic matter through the enhancement of above-ground litter production (Lugo & Waide 2013). In India, Eucalyptus is one of the prime species in Agroforestry and farmers are mostly diverting towards clonal planting material of this species for more returns in a shorter rotation period. Eucalyptus is among the most widely cultivated forest trees in the world over 22 million hectares (Nichols *et al.* 2010). Among five important trees outside forests in the state of Uttar Pradesh, the relative abundance per cent of Eucalyptus trees in rural areas is 15.86 and in an urban area, it is 8.87 (FSI, 2019). Vijayaraghavan and Sivakumar (2017) stated that Eucalyptus *hybrid* and *E. tereticornis* are the two most widely planted Eucalyptus trees in India. Many species can tolerate flooding or swamp lands and are given vernacular names e.g. flooded gum (*E. grandis*), swamp gums (*E. camphora* and *E. ovate*), river red gum (*E. camaldulensis*) and swamp mahogany (*E. robusta*). The area under agroforestry in India is estimated as 25.32 million ha (Mha), or 8.2 per cent of the total geographical area of the country. A total of 53.32 Mha, representing about 17.57 per cent of the total reported geographical area (TRGA) 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.*

2012). In recent past, clonal forestry had played a significant role in producing better production yield in shorter time. It is also well established that performance of Eucalyptus clones is superior over normal seed borne plants. Therefore, there is an urgent need for improvement in the 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).

Large-scale Eucalyptus plantations have been raised on forest & farmlands, community lands and road/rail/canal strips in India. These plantations have created a 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 seeds were 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 the local market for pole (Behera, 2016). In the eastern part of Uttar Pradesh state of India, Eucalypts are in the improving stage for adoption at a larger level and the 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 the Gangetic plains of Eastern Uttar Pradesh in the Raebareily district for identification of suitable planting material in the region.

MATERIALS AND METHODS

Study Area

The district Raebareily forms a part of the Lucknow Division. It lies between 25°49' to 26°36' North latitudes and 100°41' to 81°34' East longitudes. It covers an area of 4,609 sq. km, and is home to 3,404,004 people. On the North, it is bounded by tehsil Mohanlal ganj of district Lucknow and tehsil Haider gargh of district Barabanki, on the east by tehsil Mussafir Khana of district Sultanpur and the south east by pargana Ateha and the Kunda tehsil of district Pratap Gargh. The southern boundary is formed by the Ganga which separates it from the district of Fatehpur. On the west lies the purwa tehsil of district Unnao. The district, as a whole, is fairly compact tract of gently undulating land. The elevation varies from about 120.4 m. above sea level in the north west to 86.9 m. above sea level in the extreme south east, on the banks of the Ganga. The highest points are the crowns of the watersheds of the different drainage channel which serve to divide the district into five main physical units, The ganga Khadar, the ganag upland, the southern clay tract, the central tract or the sai upland and the Northern clay tracts. The district forms a part of the Gangetic plan which is of recent origin according to geological chronology and reveals ordinary gangetic alluvium. The district is a part of the alluvial plain confirm the same geological sequence as the plain itself. The only mineral of importance is kankar. The district is also noted for its deposits of reh and brick earth.

About the 13th century the greater part of the district was covered with extensive forests. During the period of second world war and thereafter, forest in the district were recklessly cut down. The areas of such land already planted with trees like dhak, khair, babul, shishum, neem, vilayti babul, arjuna, kanji, siras, eucalyptus, mango and Jamun are 544 hectares in tehsil Raebareily, 500 hectares in tehsil salon, 348 hectares in tehsil Dalmau and 61 hectares in tahsil Maharajganj. The climate of the Raebareily district is almost dry. Annual rainfall is about 900-1000 m.m. which is mainly from July to September. Paddy is the main Kharif crop and Wheat is the main Rabi crop in the district. Sugarcane and potato are the main cash crops of the district. Before Independence Production of paddy and wheat was 5 Quintal and 4 Quintal Per hectare respectively (Census of India 2011).

Map of district Raebareli

Establishment of experimental trial

This district lies under the Eastern Gangetic plains of Eastern Uttar Pradesh. This trial was established in the year 2016 with 19 Punjab clones in the village of Habirapur. It is a small Village/hamlet in Deeh Block in the Raebareily District of Uttar Pradesh State. It is located 52 km from the district headquarters of Raebareily, and 130 km from the State capital Lucknow. The trial was conducted under the statistical design of Complete Randomized Blocks with 3 replicates and 3 x 2 m spacing for all 19 clones of Pragati Biotech, Punjab (413,07,526, 04, K-25, 288, 2013, 2023, 2070, 2136, 3018, 2031, P-13, P-14, P-23, P-32, P-45, P-50, P-66) of 03 eucalyptus species (*E. hybrid, E. tereticornis and E. camaldulensis*) along with control for all 20 treatments. The mixture of 100g 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 five 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 data analysed statistically by standard ANOVA technique

using RBD. 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 are as following:

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*

RESULTS AND DISCUSSION

The results for evaluation of the growth performance of these clones were recorded for annual increment in measurements of total height (m) and girth at basal height; gbh (cm) for five years and are depicted in Table 1 & 2; Fig.1 & 2. The highest value of increment in gbh belonged to clones P-13 (49.04 cm) followed by P-50 (46.16 cm), P-23 (45.68 cm), 526 (44.01 cm), P- 32 (43.13 cm), 3018 (42.89 cm) and P-45 (41.91). The lowest values belonged to clone 2013 and P-66 with 32.73 and 33.26 cm respectively. The clones with good annual increment in height were P-13 (20.15 m) followed by P-50 (20.14 m). The performance of the control clone was inferior for girth and height increments as compared to the 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 for annual mean increments in height and girth showed in Tables 1 & 2. In Fig. 3, performance scores were assigned to well-performing clones based on their increments in girth and height after five years of planting. The basal area and tree volume were also calculated for clones and were superior for higher-scored clones with their respective values of girth and height increments after five years of planting (Table 3, Fig. 4 & 5). Based on growth performance parameters such as height, girth, diameter, basal area and tree volume, the clones, P-13, P-50, P-23, 526, P-32, 3018 and P-45 performed superior over other treatments in the Raebareily district. Here, all well-performing clones of the Punjab series belonged to *E. camaldulensis* only whereas clone 3018 is *E. hybrid.*

Table 1. Annual increment in height (m) in five years of planting

Clones	year 1	year 2	year 3	year 4	year 5
P-50	0.45	3.83	10.12	15.53	20.14
413	0.46	4.2	8.58	13.19	17.16
288	0.35	2.29	9.96	15.74	17.26
2023	0.44	3.42	8.67	13.9	17.5
P-45	0.44	3.08	11.06	17.3	18.83
3021	0.42	3.67	7.56	11.88	16.44
P-14	0.32	2.45	7.33	12.53	16.34
2013	0.32	2.23	6.78	10.01	13.99
P-66	0.41	3.28	6.97	11.46	14.9
3018	0.43	3.11	9.2	14.55	18.38
P-32	0.36	2.38	7.98	13.8	17.93
2070	0.45	3.71	8.94	14.56	17.74
P-23	0.33	1.6	9.72	15.51	19.27
07	0.38	2.59	8.9	14.8	18.66
K-25	0.36	2.48	7.75	13.55	16.81
2136	0.43	3.71	8.17	14.23	18.26
P-13	0.31	1.62	5.91	10.27	20.15
526	0.37	2.14	9.09	15.1	18.67
04	0.34	1.89	7.54	13.15	17.17
Control	0.33	1.39	7.19	11.87	13.64
C.D. (5%)	0.08	1.06	1.55	2.39	1.88
SE(m)	0.03	0.37	0.55	0.84	0.66
SE(d)	0.04	0.53	0.77	1.19	0.94
C.V.	14.92	27.13	13.09	12.35	7.65

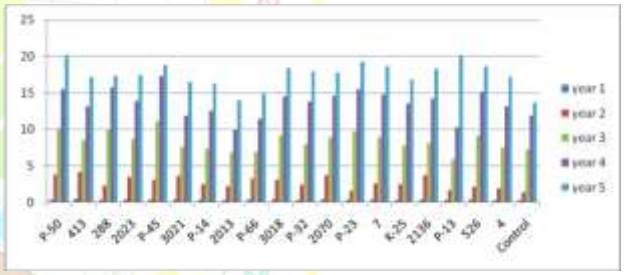

Fig.1. Annual increment in height (m) in five years of planting

The variation among clones in growth parameter may be due to genetic makeup and interactions with environmental factors. Similarly, Dhillon and Singh (2010) also found a difference in diameter growth among clones of *E. tereticornis* at the age of 3.5 years. Lal *et al* (2006) identified the best clones out of 36 *viz*., clone 2070, 285, 316, 288, 498, 286 and 2045 for Punjab's ecological condition. Luna and Singh (2009) studied the growth performance of 12 clones of Eucalyptus at Ludhiana. Clone no. 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 were 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 (Behera,2016). The clones have to be tested in target environments before deploying in plantations (Oballa *et al*. 2005).

Table 2. Annual increments in girth (cm) after five years of planting

Clones	year 1	year 2	year 3	year 4	year 5
P-50	0.91	6.26	21.56	35.49	46.16
413	1.05	6.06	19.16	32.34	36.25
288	0.88	3.64	19.03	32.83	37.01
2023	0.98	4.56	15.91	27.54	37.19
P-45	1.06	5.83	22.18	37.01	41.91
3021	0.83	6.38	14.7	24.84	35.5
P-14	0.63	6.34	13.44	23.04	37.66
2013	0.69	3.76	10.09	25.89	32.73
P-66	0.73	4.84	12.03	20.05	33.26
3018	0.94	4.85	17.58	27.03	42.89
P-32	0.75	4.55	16.71	26.43	43.13
2070	0.91	6.01	19.49	32.54	34.14
P-23	0.8	2.79	17.91	32.74	45.68
07	0.79	3.78	23.31	40.38	36.43
K-25	0.78	4.69	18.7	31.55	37.56
2136	0.63	4.88	15.01	27.04	37.64
P-13	0.66	3.6	11.96	22.94	49.04
526	0.79	3.53	19.13	33.99	44.01
04	0.89	4.48	15.95	26.69	35.59
Control	0.86	2.51	13.85	23.86	29.35
C.D.(5%)	0.20	N/A	4.90	7.40	9.61
SE(m)	0.07	1.06	1.73	2.60	3.35
SE(d)	0.10	1.50	2.44	3.68	4.73
C.V.	16.88	45.60	20.52	18.14	14.64

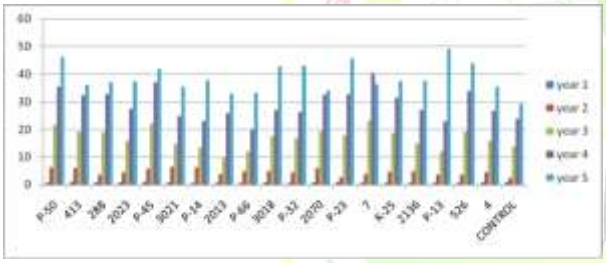

Fig. 2. Annual increment in girth (cm) after five years of planting

The fact that most clones outperformed the provenance seed lots at comparatively waterlogged conditions (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). 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). Kumar and Bangawa (2006) observed significant differences in growth attributes among seven species of *Eucalyptus* species. It is also established *E. camaldulensis* is a pure species adapted to low-to intermediate rainfall environments with a dry season of up to 8 months. Several studies have reported the significant growth performance of Eucalypt clones in the world. The results of the study confirm that clones of *E. camaldulensis* are well adaptable in the Gangetic plain region of the Raebareily district of Uttar Pradesh in India.

Table 3. Performance of clones for basal area and tree volume

Clone / Treatment	Height (m)	Girth (cm)	DBH (cm)	Basal area /tree (sq m)	Volume /tree (cu m)
P-50	20.14	46.16	14.70	0.0012	0.34167
413	17.16	36.25	11.54	0.0009	0.17953
288	17.26	37.01	11.79	0.0009	0.18823
2023	17.5	37.19	11.84	0.0009	0.19271
P-45	18.83	41.91	13.35	0.0010	0.26333
3021	16.44	35.5	11.31	0.0009	0.16496
P-14	16.34	37.66	11.99	0.0009	0.18451
2013	13.99	30.73	9.79	0.0008	0.10518
P-66	14.9	33.26	10.59	0.0008	0.13123
3018	18.38	42.89	13.66	0.0011	0.26920
P-32	17.93	43.13	13.74	0.0011	0.26555
2070	17.74	34.14	10.87	0.0009	0.16462
P-23	19.27	45.68	14.55	0.0011	0.32014
O7	18.66	36.43	11.60	0.0009	0.19717
K-25	16.81	37.56	11.96	0.0009	0.18881
2136	18.26	37.64	11.99	0.0009	0.20597
P-13	20.15	49.04	15.62	0.0012	0.38582
526	18.67	44.01	14.02	0.0011	0.28791
04	17.17	35.59	11.33	0.0009	0.17316
Control	13.64	31.35	9.98	0.0008	0.10673

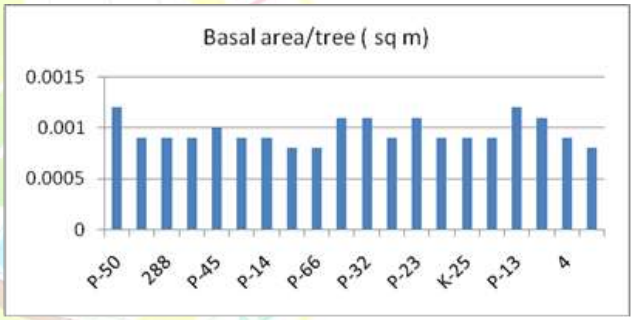

Fig 4. Basal area /tree (sq/m)

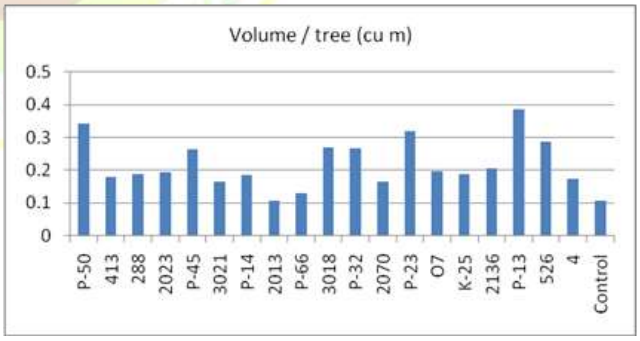

Fig. 5. Volume /tree (cu m)

CONCLUSION

It is clear from the study that the 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, concerning the productivity of a large eucalypt plantation to pursuing site-specific selection and deployment strategies for the highly 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 concerning increased clonal plantation with site-specific clones would be more beneficial. Therefore, clonal plantations of Eucalyptus under an agro-forestry system should be encouraged and integrated with the planned development of wood-based industries through innovative policy changes. Extension services must be strengthened for taking the research findings from lab to land and maximizing the benefits of the vast potential of clonal technology for the society and farmers of our country. Thus, suitable clones of eucalypts may improve agroforestry in the region of eastern UP.

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REFERENCES

Behera, L.K. 2016. Clonal variation in physical, anatomi- cal and chemical properties of wood of Eucalyptus. *Ph.D. Thesis*, Navsari Agricultural University, Navsari, 215.

Bindumadhava, H., Jagdish T., K. Mahavishnan , A. P. Upadhyay, Mohan Varghese and N. Sharma 2011. Clonal propagation in *Eucalyptus camaldulensis* using mini-cutting technique, *Current science*, **101**(12): 25.

Census of India 2011. Uttar Pradesh District Census Handbook - Rae Bareli, Part A (Village and Town Directory).

Dhillon, G.P.S and Singh, A. 2010. Variation in growth traits among progenies of *Eucalyptus tereticornis* Sm. under flood- plain conditions of Punjab. *Indian J. Agroforestry*, **12**(1): 91-94.

Dhyani, S. K. 2012.Agroforestry interventions in India: Focus on environmental serices and livelihood security. *Indian Journal of Agroforestry.* 13(2): 1-9.

FSI 2019. *India State of forest Report 2019,* Published by Forest Survey of India (Ministry of Environment Forest and Climate Change) Kaulagarh road, P.O. IPE Dehradun – 248195, Uttarakhand, India, vol. **2**, 283.

Kumar, R. and Bangarwa, K. S., 2006. Clonal evaluation in *Eucalyptus tereticornis* Sm. *Environt Ecol*, **24** (4): 1188 – 1191.

Lal, P. 1993. Improving land productivity and returns from agroforestry plantations. *Indian Forester*, **119**(6): 431- 440.

Lal, P. 2006. Licensing of wood Based Industries- why Punish Farmers Greening the Country? The *Indian Forester*, **132**(8) :1071-1074.

Lugo E. and Waide R.B. 2013. Catastrophic and background disturbance of tropical ecosystems at the Luquillo experimental forest. *Journal of Biosciences*, **18**(4): 475–481.

Luna, R.K. and Singh, B. 2009. Estimates of genetic variability and correlation in Eucalyptus hybrid progeny for early selection. *Indian Forester*, **135**(2): 147-160.

Nichols, J.D., Smith, R.G.B, Grant, J.C. and Glencross, K. 2010. Subtropical eucalypt plantations in Eastern Australia. *Journal of Australian Forest* **73**: 53 – 62.

Patil, H. Y., Patil,S. J., Mutanal, S. M. and Shahapurmath, G.2012. Growth and productivity of different *Eucalyptus* species on degraded land, *Karnataka J. Agric. Sci.*,**25**(1): 92-93.

Sandhu N.K., Dhillon G.P.S. and Brar A.S. 2020. Growth performance of *Eucalyptus* clones under varying moisture levels. *Ind J Agroforest*, **22**: 74-77.

Sheoran, O.P; Tonk, D.S; Kaushik, L.S; Hasija, R.C and Pannu, R.S 1998. Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & Computer Applications by D.S. Hooda & R.C. Hasija Department of Mathematics Statistics, *CCS HAU, Hisar* ,139-143.

Silva C.D., Nascimento J.S., Scarpinati E.A. and Paula R.C. 2014. Classification of *Eucalyptus urograndis* hybrids under different water availability based on biometric traits. *Systems*, 23: 209-215.

Vijayaraghavan, A. and V. Sivakumar 2017. Selection of site-specific Eucalyptus camaldulensis and Eucalyptus tereticornis clones for Ariyalur region (Tamil Nadu) based on its higher Productivity, *IJRDO-Journal of Biological Science*, **2**(3): 36-48

Vijayaraghavan, A., Sivakumar, V., Jayaraj, R.S.C., Panneer Selvam, K. and Azhagarasi, P.V. 2016. Identification of *Eucalyptus camaldulensis* clones suitable to water logged area in Karaikkal (Puducherry). *'International Journal of Environmental Research and Development',* **17**(3):138-145.

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