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Biomass production potential of *Eucalyptus tereticornis* Smith plantations under degraded soils

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ABSTRACT

The study on biomass production potential of seven years old *Eucalyptus tereticornis* plantations managed under high density short rotation (HDSR) system was conducted in the mid- hill zone of Himachal Pradesh at the experimental farm of the department of Silviculture and Agroforestry, UHF, Solan. The experiment consisted of nine treatment combinations, comprising of three planting densities *i.e.* D_1 (27, 778 trees ha^{-1}), D_2 (12,346 trees ha^{-1}) and D_3 (6,944 trees ha^{-1}) and three nitrogen-levels *i.e.* No (No fertilizer), N_{50} (50 kg N ha^{-1}) and N_{100} (100 kg N ha^{-1}). The results from the study revealed that decreasing plant density had a significant increasing effect on survival percentage, tree height, diameter and all biomass components. The studies further revealed that the single application of N-fertilizer at the time of planting is beneficial but with time its influence got leveled off, if not applied again.

Key Words:

Biomass, *Eucalyptus tereticornis*, high density, N-application. short rotation, survival

INTRODUCTION

The present forest resource and low production of forests cannot meet the much needed demands of fuel wood, timber and raw material to industries in large quantities under inflating population pressure. Therefore, there is need to pay more attention to production forestry which involves raising plantations of fast growing species under Short Rotation Intensive Culture (SRIC) and High Density Short Rotation (HDSR) management systems, especially in tree farming which have opened up new vistas in wood biomass production (Dogra 1989). The concept of short rotation forestry is almost three to four decades old with very little scientific history (Szego and Kemp 1973). There are a number of fast growing potential tree species like *Populus, Eucalyptus, Sesbania, Paulownia* (Pandey and Sharma 1989) and *Ailanthus, Melia, Acrocarpus, Casuarina, Gmelina, etc.* which can be exploited under short rotation forestry in different parts of the country. But, the *Eucalyptus* has an edge over all these fast growing tree species because of its adaptability, suitability and wider distribution under varying environmental conditions.

The popularity of *Eucalyptus* can be mirrored with the fact that more than 80 countries have shown an interest in this genus, planting more than 10 million ha or approximately one quarter of tropical forest plantations. Interestingly, even a common man knows this genus and familiar with its diversified end uses. Out of various species of *Eucalyptus* introduced into India in the regime of Tippu Sultan, from 1782 to 1802 at Nandi hills, Bangalore and Sultanpet area in the Deccan. *Eucalyptus tereticornis* has been the most successful with the respect to its productivity and distribution under a multitude of edapho-climatic situations. This species is being currently managed through HDSR as well as SRIC systems in order to mitigate the problems of wood biomass. Since, these management systems (HDSR and SRIC) have very little scientific history, regarding to the sustenance of soil environment vis-à-vis usable wood biomass produced, but are already in vogue and need immediate attention so as to make the systems economically more viable and environmentally sound. Therefore, by analyzing the present scenario of information available and importance of this species, an attempt has been made in the present experiment to study the survival per cent, its growth and biomass production potential of *Eucalyptus tereticornis* plantation managed under high density short rotation system under degraded soil conditions.

MATERIALS AND METHODS

The present investigations were carried out in the seven years old *E. tereticornis* plantation managed under three planting densities in the experimental area of the Department of Silviculture and Agroforestry, College of Forestry, University of Horticulture and Forestry, Solan, Himachal Pradesh. The experimental site is located in the Mid-Hill zone of Himachal Pradesh at an elevation of 1200 m above mean sea level, representing 30° 51'N latitude and 76° 11'E longitude (Survey of India Toposheet No. 55 F/1). The average annual temperature of the area ranges from 30°C to 32°C, whereas; mean annual temperature (MAT) is 18°C. The area receives an annual average rainfall ranging from 100 to 130 cms most of which is received during monsoon periods.

The experiment consisted of nine treatment combinations comprising of three planting densities *i.e.* D_1 (60 cm x 60 cm, accommodating 27, 778 trees ha^{-1}), D_2 (90 cm x 90 cm, accommodating 12,346 trees ha^{-1}) and D_3 (120 cm x 120 cm, accommodating 6,944 trees ha^{-1}) and three nitrogen-levels *i.e.* No (No fertilizer), N_{50} (50 kg N ha^{-1}) and N_{100} (100 kg N ha^{-1}). The experiment was laid out in Randomized Block Design (RBD) with three replications.

The observations were recorded for survival per cent, tree height, diameter at breast height and biomass components *i.e.* leaf, branch, bole, above ground biomass, root biomass and total above ground and below ground biomass. For survival per cent, all the existing trees in the experimental plots were counted and the survival was expressed as percentage. For above ground biomass estimation, 50% of the population was clear felled in each replication using stratified mean tree technique (Art and Mark 1971). All the trees were measured for diameter at breast height (dbh) and height. Fresh weight was recorded in the field for each component, separately (leaves, branches and bole). Complete root system of sample trees representing the diameter range were excavated for the determination of underground biomass by making a trench around the main stem. All possible care was taken, so that not a single rootlet left in the soil and fresh weight was recorded in the field. Representative samples of each component were collected for their dry weight estimation.

Biomass of individual component was worked out by using formula:

Dry matter

$$= \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} x \text{ Total fresh weight of the component}$$

Total biomass was computed by summing the dry weight of the individual component and expressed as kg plant^{-1} and kg ha^{-1}, separately. The entire data generated from the present investigations were put to statistical analysis in accordance with procedures outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Survival per cent

Plant per cent in each plot was significantly better irrespective of plant density. The data recorded in Table 1, revealed that the rate of survival was maximum (97.12%) at the lowest plant density i.e. D_3 which tended to decline significantly at the maximum density (D_1) to its lowest value of 94.03 per cent. The plant per cent in density D_2 and D_3 was statistically alike. Nitrogen application to the *Eucalyptus tereticornis* plants exercised an influence on the per cent survival similar to the planting density but the increase in survival per cent with the increasing N-levels, as such was found to be statistically non-significant (Table 2).

Growth and development

The growth and development of the trees have been measured in terms of plant height and diameter. Plant height increased with decreased in plant density (Table 1). It was found to be maximum (6.44 m) at density D_3 and minimum (5.77 m) at D_1. The data revealed that increase in plant height, however was marginal. Similar trend was noticed for dbh as significantly higher value was recorded at density D_3 (4.97 cm) over D_2 (3.96 cm) and D_1 (3.61 cm).The latter two densities were found to be statistically at par with each other. Nitrogen application increased the plant height and diameter of the trees with the application of N-levels (Table 2), but as such the influence of nitrogen application was found to be statistically non-significant.

Biomass and its partitioning

Planting density influenced the biomass yield of different tree components as well as the total biomass production significantly (Table 3). Analysis of the data presented in the table revealed that leaf biomass per plant increased with the decrease in plant density. Density D_3 produced significantly higher leaf biomass (0.420 kg) over D_2 (0.326 kg) and D_1 (0.297 kg) density. Branch, bole and root biomass per plant, followed a trend similar to leaf biomass with respect to planting density showing better biomass production at density D_3. Total biomass production due to planting density followed a trend, which is consistent with the trends exhibited by an individual component viz. leaf, branch, bole and root as maximum total biomass production (9.12 kg) was registered under the density D_3 followed by D_2 (7.23 kg) and D_1 (5.72 kg). It was further observed from the data there was a increase of 26.31 and 54.49 per cent in total biomass production with decrease in plant population from D_1 to D_2 and D_1 to D_3, respectively. Aboveground biomass contributed 80.05, 79.49 and 78.16 per cent, whereas, belowground biomass contributed 19.95, 20.51 and 21.84 per cent of the total biomass at D_1, D_2 and D_3 densities, respectively. The effect of nitrogen application on biomass yield of individual components viz. leaf, branch, bole, root as well as the whole tree biomass was found to be non-significant (Table 4). However, each component has tended to attain more biomass (kg plant^{-1}) with the increase in N-levels.

Survival per cent, plant height, diameter at breast height and biomass production in different tree components was superior in density D_3 in comparison to D_2 and D_1 (having minimum value for all above mentioned parameters). This trend is obvious due to the less plant competition for space, light, nutrients and moisture, *etc.*

Saravanan 2019 reported that biomass variation also varies with clones. The results are also in line with the findings of Malik (1987) who observed similar effects of plant spacing in *E. tereticornis* in nursery stage; Sharma (1989) also reported that higher plant density in *Leucaena leucocephala*, *Melia azedarach* and *E. tereticornis* yielded less biomass.

Total biomass computed on per hectare basis was found to increase significantly with increase in plant density (Table 3). It is evident from the findings that total biomass per plant decreased, whereas total biomass per hectare increased with the increased in plant density. The increase in total biomass per hectare basis may be due to the more number of stems per hectare. Similar findings indicating a direct relationship between biomass per hectare basis and plant density were also reported by other workers (Hu et al. 1980; Van Den Beldt et al. 1982; Tondon et al. 1988; Sharma 1989 and Pal and Panwar 2013). Steinobeck et al. (1972) in Sycamore and Zavitkovski et al. (1976) in *Populus* species also reported that close spacings generally gave the greatest MAP in first few years and hence, higher biomass per hectare. However, as the plantations grow older and occupy the site, the yield of widely spaced plots gradually increased towards that of narrow spaced plots and sometime equals or even excels them.

The results pertaining to the effect of nitrogen application on survival per cent, growth attributes and biomass production of different tree components as well as whole tree attained higher values with the increase in N-levels, but the increase in above parameters was found to be statistically non-significant (Table 2 and 4) This non-significant increase due to application of various N-levels reveals that in *E. tereticornis* plants have attained significantly better growth and biomass initially but the initial gains thus obtained have been levelled off with the increase in growth period. Therefore, it is suggested from the findings of present study that nitrogen should be applied either in split doses or should be applied in subsequent years as it is noticed in the present study that after a period of time, the initial gains got levelled off.

Table 1. Effect of planting density on survival, growth and development of *E. tereticornis* under degraded soils

Density	Survival (%)	Plant height (m)	Diameter at breast height (cm)
D_1	94.03	5.77	3.61
D_2	96.76	6.14	3.96
D_3	97.12	6.44	4.97
SEm±	1.21	0.29	0.19
CDat 5%	2.57	0.62	0.41

Table 2. Effect of N-levels on survival, growth and development of *E. tereticornis* under degraded soils

N-level	Survival (%)	Plant height (m)	Diameter at breast height (cm)
N_0	95.47	5.96	3.99
N_{50}	95.78	6.16	4.22
N_{100}	96.66	6.22	4.31
SEm±	1.21	0.29	0.19

CDat 5%	NS	NS	NS

Table 3. Effect of planting density on biomass production in *E. tereticornis* (kg plant^{-1}) under degraded soils

Parameter	Density D_1	D_2	D_3	SEm±	CD at 5%
Leaf	0.297 (8262)*	0.326 (4031)	0.420 (2935)	0.039 (612)	0.083 (1298)
Branch	0.295 (8209)	0.400 (4938)	0.535 (3721)	0.057 (714)	0.121 (1513)
Bole	3.981 (110600)	5.012 (61880)	6.168 (42830)	0.493 (6686)	1.046 (14173)
Above ground biomass	4.574 (127071)	5.739 (70849)	7.125 (49486)	0.567 (7346)	1.203 (15569)
Root	1.141 (31690)	1.480 (18270)	1.990 (13820)	0.166 (2794)	0.353 (5924)
Total biomass	5.715 (158700)	7.219 (89130)	9.115 (63310)	0.675 (9390)	1.432 (19906)

* Figures in parenthesis are for biomass production kg ha^{-1}

Table 4. Effect of N-levels on biomass production in *E. tereticornis* (kg plant^{-1}) under degraded soils

Parameter	N-level N_0	N_{5-}	N_{100}	SEm±	CD at 5%
Leaf	0.332 (4589)*	0.338 (5331)	0.378 (5309)	0.03 (612)	NS
Branch	0.365 (4831)	0.368 (5782)	0.478 (6285)	0.05 (713)	NS
Bole	4.763 (64980)	5.012 (75500)	5.387 (74810)	0.49 (6685)	NS
Above ground biomass	5.461 (74400)	5.737 (86613)	6.239 (86404)	0.57 (7346)	NS
Root	1.449 (20140)	1.525 (21920)	1.636 (21720)	0.166 (2794)	NS
Total biomass	6.910 (94540)	7.262 (108500)	7.876 (108100)	0.675 (9389)	NS

*Figures in parenthesis are for biomass production kg ha^{-1}

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