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Biomass production of *Eucalyptus tereticornis* Smith plantation managed under high density plantation system

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ABSTRACT

Biomass production potential of seven years old *Eucalyptus tereticornis* plantation managed under high density plantation system was studied in the mid-hill zone of Himachal Pradesh at the experimental farm of Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP. The experiment consisted of nine treatment combinations comprising of three plant densities and three N-levels. It was laid out in randomized block design with three replications. The results of the study revealed that survival per cent, tree height and diameter (dbh) were higher in the lowest plant density ie D_3 (6944 plant ha^{-1}) and minimum under density D_1 (27778 plant ha^{-1}) having maximum plant population. Biomass production per plant in all tree components decreased significantly with increase in plant density. An increase of 1.26 and 1.59 times in total biomass production with the decrease in plant population from D_1 to D_2 and D_1 to D_3 respectively was recorded. However results on hectare basis for the same parameters were exactly opposite to it and total biomass production under density D_1 was 2.50 times higher than D_3 and 1.78 times higher than the density D_2.

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Keywords: Biomass, above ground, plantation, Eucalyptus tereticornis, high density

INTRODUCTION

India is the world's seventh largest and one of the most heavily populated countries. The nation today faces a near crisis situation both economic as well as environmental. This is particularly the outcome of overuse and abuse of the various natural resources under the inflating population pressure. The degradation is visible in all the renewable and non-renewable resources yet the forest wealth in particular has met the colossal depletion. Despite framing the national policies and enacting new acts in post independence period our efforts in promotion of scientific forestry and enhancing the forest cover have been quite dismal.

The condition of our forests is extremely poor and constitutes less than 2 per cent of the world's forest area supporting over 15 per cent of world's human population and nearly equal percentage of the cattle population. Stating the scenario of Indian forestry the figures are not encouraging. The total forest area in the country is 23.41 per cent of its geographical area against 33 per cent required as per the NFP of 1988 whereas the forest cover in the country is 21.02 per cent (Anon 2009). Besides our forests are neither uniformly stocked nor equitably distributed and this can be gauged from the data that almost 41.74 per cent of forest cover is having canopy density between 10 to 40 per cent (Anon 2009). Huge tracts of Himalayas and other regions have been turned into wastelands and the process is still continuing at an alarming rate resulting in severe soil erosion, floods, droughts, landslides, receding glaciers, silting of reservoirs and an air and water pollution. The misery caused to the entire nation due to this unprecedented eco-degradation is enormous and warrants immediate remedial measures.

The present available forest resources and low production of our forests cannot meet the much needed demands of fuel wood, timber and raw material to industries in large quantities under inflating population pressure (Khoshoo 1997). Keeping in view these challenges we must pay more attention to increase productivity to save and improve area under forest and tree cover as well as raising of large scale plantations of fast growing multipurpose tree species including exotics under new management systems.

Short Rotation High Density (SRHD) and Short Rotation Intensive Culture (SRIC) management systems especially in tree farming have opened up new vistas in wood biomass production (Dogra 1989). The concept of short rotation forestry is almost 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 Masoodi 1996) and *Ailanthus*, *Acrocarpus*, *Casuarina*, *Gmelina* etc which can be exploited under these plantation systems.

Furthermore 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. Out of various species of *Eucalyptus* introduced in India *E tereticornis* has been the most successful with respect to its productivity and distribution under a multitude of edapho-climatic situations. This species is being currently managed under SRHD as well as SRIC systems in order to mitigate the problems of wood biomass. These management systems have very little scientific history with regard to the sustenance of soil environment vis-a-vis usable wood biomass produced but are in vogue and need immediate attention so as to make the systems economically 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 investigations to quantify the productivity potential of *E tereticornis* managed under high density plantation system.

MATERIALS AND METHODS

The present investigations were carried out in the seven years old *Eucalyptus tereticornis* plantation managed under three planting densities in the experimental area of the Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP. 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 3°C to 32°C whereas mean annual temperature (MAT) is 18°C. The area receives an annual rainfall ranging from 20 mm to 330 mm most of which is received during monsoon periods.

The experiment consisted of nine treatment combinations comprising of three planting densities viz 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 6944 trees ha^{-1}) and three nitrogen-levels viz N_0 (no fertilizer), N_{50} (50 kg N ha^{-1}) and N_{100} (100 kg N ha^{-1}) applied at the time of plantation. The experiment was laid out in randomized block design (RBD) with three replications. All the survived trees in the experimental plots were counted and the survival was expressed as percentage. All the trees were measured for diameter at breast height (dbh) and height. For the above ground biomass estimation fifty per cent of the population was clear felled in each replication using stratified mean tree technique (Art and Marks 1971) whereas for underground biomass estimation complete root system of sample trees representing the whole diameter range were excavated by making a trench around the main stem.

Fresh weight was recorded in the field for each component separately ie leaf, branch, bole and root. Representative samples of each component were collected for their dry weight estimation. Biomass of individual component was worked out by using formula:

$$\text{Dry matter} = \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \times \text{Total fresh weight}$$

The total biomass (above ground biomass plus below ground) was computed by summing up the dry weight of the individual components and expressed as kg $tree^{-1}$ and kg $hectare^{-1}$ 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, tree height and diameter

The data presented in Table 1 depict that the rate of survival was maximum ie 97.12 per cent at the lowest density (D_3) which tended to decline significantly at the maximum density (D_1) to its lowest value of 94.03 per cent. Overall the survival (%) in each density was better irrespective of the plant density ie more than 94 per cent. Similar findings indicating a relationship with survival and spacing were also reported by Lohani (1980) highlighting higher survival under lower densities due to the competition among the plants for space, light, nutrients, moisture, etc. Plant density also influenced the growth attributing characteristics viz tree height and diameter significantly. Growth of both these parameter increased with the decrease in plant population. Relatively lower response of tree height in comparison to diameter to planting densities in the present study is in accordance with the findings of Chaturvedi (1983, 1986), Van Den Beldt et al (1982) and Sharma (1989).

Biomass production

The above ground biomass production increased significantly with the decrease in plant density (Table 2). The highest above ground biomass was recorded under density D_3 (7.125 kg) followed by density D_2 (5.739 kg) and D_1 (4.574 kg). It was further observed from the analysis of the data that bole component was the main contributor to the total above ground biomass in all the planting densities followed by branches and leaves. The per cent contribution of bole to the total above ground biomass ranged from 86.53 to 87.27 per cent irrespective of the planting density.

Table 1. Effect of planting density on survival, tree height and diameter of *Eucalyptus tereticornis*

Density	Survival (%)	Tree height (m)	Diameter (cm)
D_1 (27,778 trees ha^{-1})	94.03	5.77	3.61
D_2 (12,346 trees ha^{-1})	96.76	6.14	3.96
D_3 (6,944 trees ha^{-1})	97.12	6.44	4.97
$SE_{m\pm}$	1.21	0.29	0.19
$CD_{0.05}$	2.57	0.62	0.41

Table 2. Effect of planting density on biomass production in Eucalyptus tereticornis (kg plant^{-1})

Parameter	D_1 (27,778 trees ha^{-1})	D_2 (12,346 trees ha^{-1})	D_3 (6,944 trees ha^{-1})	$SE_{m\pm}$	$CD_{0.05}$
Leaf	0.297 (8262)*	0.326 (4031)	0.420 (29.35)	0.039 (612.19)	0.083 (1297.8)
Branch	0.295 (8209)	0.400 (4938)	0.535 (3721)	0.057 (713.77)	0.121 (1513.1)
Bole	3.981 (110600)	5.012 (61880)	6.168 (42830)	0.493 (6685.9)	1.046 (14173)
Total above ground	4.574 (127071)	4.574 (70849)	7.125 (49486)	0.567 (7346.3)	1.203 (15556.8)
Root	1.141 (31690)	1.480 (18270)	1.990 (13820)	0.166 (2794.4)	0.353 (5923.8)
Total (above and below ground biomass	5.715 (158700)	7.219 (89130)	9.115 (63310)	0.675 (9389.8)	1.432 (19906)

*Biomass production in kg ha^{-1}

It is also evident from Table 2 that root biomass varied significantly under different plant spacings. Density D_3 registered highest root biomass of 1.990 kg per plant followed by density D_2 (1.480 kg) and D_1 (1.141 kg). However the values under density D_2 and D_1 were statistically at par with each other.

Total biomass production under different planting densities followed a trend which was consistent with the trends exhibited by an individuals tree components viz leaf, branch, bole and root. It was also observed from the data that there was an increase of 1.26 and 1.59 times in total biomass production with the decrease in plant population from D_1 to D_2 and D_1 to D_3 respectively. Such a decline in total biomass computed on per plant basis with increase in plant density can be ascribed to an intense competition at the close spacings. The present results are in line with the findings of Malik (1987) who observed similar effects of plant spacings 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.

It is also noticed from the data figured in Table 2 that total biomass on per plant basis decreased whereas on hectare basis it increased significantly with the increase in plant density. Total biomass production under density D_1 was 2.50 times higher than D_3 and 1.78 times higher than the density D_2. The increase in total biomass on per hectare basis may be due to more number of stems per hectare. The above findings can be substantiated with the observations made by Steinbeck (1972) in sycamore and Zavitkovski et al (1976) in poplar who reported that close spacing generally gave greatest MAP in first few years and hence higher biomass per hectare. However as the plantation grow older and occupy the site the yield of widely spaced plots gradually increases towards that of narrow spaced plots and sometimes equals or even excels them.

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