Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 8, No. 4, p. 20-25, 2016
http://www.innspub.net

INNSPUB
RESEARCH PAPER
OPEN ACCESS

Biomass and carbon sequestration rate in a young *Eucalyptus* hybrid plantation of Terai Central Forest Division

Krishna Kumar Tamta[1], Ashish Tewari[1*], Vivek Pandey[2]

[1]*Department of Forestry and Environmental science, Kumaun University,Nainital, India*

[2]*Conservator Research, Forest Training Institute, Haldwani, India*

Article published on April 18, 2016

Key words: Biomass, Carbon Sequestration, *Eucalyptus* hybrid, Plantation, Terai.

Abstract

Biomass and carbon sequestration rate in a 2 year old plantation of *Eucalyptus* hybrid was estimated in Terai central forest division of Uttarakhand over a one year period extending between October-2009 to September-2010. 20 permanent plots of 0.1 ha were placed randomly in the plantation site of 10 ha. The biomass was calculated by using previously developed allometric equations for two year old *Eucalyptus* hybrid plantation. The total tree density in *Eucalyptus* hybrid plantation was 1830 tree ha^{-1}. The total tree biomass was 7.18 t ha^{-1} in year 1 which increased to 15.56 t ha^{-1} in year 2. The carbon sequestration rate of this plantation was 4.19 t ha^{-1} yr^{-1}.The contribution of the above ground biomass was close to 79.49% and below ground biomass was 22.47% in total tree biomass. Plantation of fast growing species like *E.*hybrid have a huge carbon accumulation potential. Large scale plantations of fast growing species particularly on wastelands can significantly store large carbon stocks and contribute in atmospheric carbon mitigation.

***Corresponding Author:** Ashish Tewari ✉ atewari69@gmail.com

Introduction

According to UNFCCC (2010) the process of removing carbon from the atmosphere and depositing it in a reservoir is carbon sequestration. The accumulation of CO_2 and other greenhouse gases in the atmosphere is expected to cause observable climatic changes in the coming century. Approximately 22% of the annual global carbon dioxide emission results from human activities such as deforestations (Jina *et al.* 2008). Carbon accumulations by terrestrial forest ecosystems have a paramount role in reducing the even increasing problem of atmospheric carbon increase worldwide. Forest species vary significantly in their carbon sequestering potential, hence knowledge of the sequestering capacity of individual species is essential (Chauhan *et al.,* 2004).

The total global potential through afforestation and reforestation activities for the period 1995–2050 is estimated to sequester between 1.1 and 1.6 Pg C (1 Pg=Peta gram, 10^{15}g) per year, of which 70% would occur in the tropics (IPCC, 2000). However, there is a large variation in the carbon sequestration potential of different plantation species (FAO, 2003; Negi and Chauhan, 2002). Carbon management in forests is a global concern to mitigate the increased concentration of greenhouse gases in the atmosphere. Reviving forest cover and finding low cost methods to sequester carbon is emerging as a major international policy goal. However, the global forest cover is dwindling fast in view of high biotic pressure, industrialization, urbanization, land use changes and conversion of forests to agricultural land.The global area of plantation was 1.39×10^8 ha in 2005 with predictions for an annual expansion of 2% (Van Dijik and Kumar, 2007).

Soil organic carbon (SOC) also plays a very significant role in the global carbon cycle, as it is the largest terrestrial carbon pool. Soil can be a source (CO_2, CH_4 and N_2O) or sink (CO_2 and CH_4) of greenhouse gases depending on land use and management (Lal, 1999). The various studies carried out on different plantations in the Terai region have highlighted the contribution of plantations programs in global carbon cycle (Bargali*et al.* 1992; Lodhiyal and Lodhiyal, 1997; Singh *et al.* 2011). The young plantations are generally considered to have insignificant biomass and carbon sequestration rates and hence given limited importance. The present study focuses on the estimation of biomass and carbon sequestration rate of a young *Eucalyptus* hybrid plantation and soil carbon to highlight the importance of plantations of this species in carbon saving.

Materials and methods

Site description

The study was carried out in Bhakra range of Haldwani forests. The site was dominated by a pure plantation of *Eucalyptus* hybrid in10 ha area. The site is located in Terai Central Himalaya forest Division of Uttarakhand. Geographically Terai forest lies between 29°1' 30" N to 29°16' 40" N latitudes and 79°13'45" E to 79°31' E longitudes. The soil is deep fertile, moist alluvial loam conspicuous being free from boulders and gravel (Bargali *et al.*, 1992). The general appearance of the tracts is gently sloping towards the south east; topographically the region is akin to the plains having good forests. The study area is located in subtropical climatic condition and the rainfall occurs during the monsoon (mid-June to middle September). During the study period the annual rainfall was 155 cm. Temperature varied according to climatic condition, which tends to change drastically. January and February were the coldest months while May and June were the hottest months. Generally temperature remained high between March and July, where it reached close to mean maximum of 42°C.

Tree vegetation analysis

The vegetative study was conducted during (September) 2009 by placing 20 quadrats of 0.1 ha in yr-1. Diameter of all trees was measured using a digital calliper as the circumference of the trees was generally less than 12 cm (Mitutoyo make, 0-15 cm measuring range) followed Singh *et al.* (2011). The

field data was analysed for density and basal area following Curtis and Mclntosh (1950).

Soil parameters

Walkey and Black titration method was used for soil carbon estimation (Jackson, 1967).6 pits were randomly dug upto 30 cm depth over the site (October 2009) and 3 replicate of 100g soil (R1, R2, and R3) were taken. From each pit soil sample were collected from different soil layer 0-10, 10-20, 20-30 cm for estimation of soil carbon. Soil samples were collected from the same soil layers for calculation of soil bulk density, soil moisture content, and soil water holding capacity (Mishra, 1968).

Tree biomass and carbon accumulation

Biomass was estimated in yr-1 and yr-2 using allometric equation earlier developed by Bargali *et al.* (1992) for 2 year old *Eucalyptus* hybrid plantations in Terai region of Uttarakhand. The mean dbh of tree species was used to calculate the biomass of different tree component. Total biomass of each year was calculated by summing biomass of different tree component. The biomass of different components (bole, branch, twig, foliage, stump root and fine roots) was calculated in 2009 (B1) and in 2010 (B2). The change in biomass of Yr 2 – Yr 1 yielded the annual biomass accumulation (Karky and Tewari, 2007). 50% of annual biomass accumulation was taken as carbon sequestration rate (Pant and Tewari, 2014).

Results and discussion

Stand characteristics and soil parameters

The tree density of the pure young *Eucalyptus* hybrid plantation was 1830 trees/ha with total basal area of 0.62m²/ ha. Lodhiyal *et al.* (2002) have reported 625 tree ha^{-1} in a Shisham plantations in the Terai region of Kumaun. Bargali *et al.* (1992) have reported 2000 tree ha^{-1} in young plantations of *Eucalyptus*. However; variation in number of plants ha^{-1} is common depending upon the purpose and objective of management.

The soil organic carbon percent in the given site ranged between 1.1±0.05% and 0.51±0.03% between 0-30 cm depths. The percent of carbon in the top most soil layer 0-10 cm was maximum 1.1 ±0.05 % and declined with increasing depth (Table 1). Singh *et al.* (2011) have also reported low soil organic carbon in top layer (0-30 cm) in Terai region. Soil bulk density in the given forest area varied from 1.66±0.01 to 1.15±0.04 g/cc. In the top most layer i.e. 0-10 cm depths it was 1.66±0.01 g/cc, between 10-20 cm depth it was 1.20±0.02 g/cc and in 20-30 cm depths it was 1.15±0.04 g/cc (Table 1).

Table 1. Tree density, soil carbon, soil bulk density, soil moisture content and soil water holding capacity of plantation.

Forest Type	Tree density (individual ha^{-1})	Soil Depth (cm)	Soil Carbon (%)	Soil Bulk density (g/cc)	Soil Moisture Content (%)	Soil Water holding Capacity (%)
Eucalyptus hybridplantation	1830	0-10	1.10 ±0.05	1.66 ±0.01	3.63 ±0.02	29.47 ±0.01
		10-20	0.55 ±0.02	1.20 ±0.02	3.08 ±0.01	23.41 ±0.03
		20-30	0.51 ±0.03	1.15 ±0.04	3.54 ±0.01	34.69 ±0.01

The soil moisture content of given site varied from 3.63±0.02% to 3.54±0.01%. The soil moisture content did not show any major variation with soil depths. (Table 1) The soil water holding capacity of given site varied from 29.47±0.01% to 34.69±0.01% and increased with depth. (Table 1).

Tree biomass accumulation and carbon sequestration rate

The biomass of this young plantation in yr-1 was 7.1 t ha^{-1} which increased to 15.5 t ha^{-1} in yr-2. The above ground biomass in yr-1 was 5.51 t ha^{-1} and below ground biomass was 1.65 t ha^{-1}. In yr-2 the above ground biomass was 12.04 t ha^{-1} and below ground biomass was 3.48 t ha^{-1}. The biomass change between yr-1 and yr-2 was 8.36 t ha^{-1}. The plantation was accumulated carbon at the rate of 4.19 t c $ha^{-1}yr^{-1}$ (Table 2).

Table 2. Component wise (above and below ground parts) tree biomass distribution and change in biomass (yr-2 – yr-1) (tha^{-1}) and carbon sequestration rate (t c ha^{-1}yr^{-1}) in *Eucalyptus* hybrid plantation at Bhakra Range of Haldwani. (The values in parenthesis show the percentage contribution of the tree component in total biomass.)

	Biomass (t ha^{-1})		Change in Biomass	Carbon Sequestrated
Component	Year 1	Year 2	(yr-2 - yr-1) (t ha^{-1})	(50% of Biomass yr-2 -yr-1) (t c ha^{-1}yr^{-1})
Bole	4.40 (61.24%)	9.28 (59.6%)	4.88	2.44
Branch	0.49 (6.80%)	1.27 (8.19%)	0.78	0.39
Twig	0.10 (1.40%)	0.21 (1.41%)	0.11	0.05
Foliage	0.52 (7.34%)	1.28 (8.26%)	0.76	0.38
Total above ground	5.51 (76.7%)	12.04 (77.49%)	6.53	3.26
Stump root	0.96 (13.30%)	2.03 (13.09%)	1.07	0.53
Lateral root	0.53 (7.21%)	1.09 (7.03%)	0.56	0.28
Fine root	0.16 (2.20%)	0.36 (2.35%)	0.20	0.10
Total below ground	1.65 (22.7%)	3.48 (22.47%)	1.83	0.91
Total	7.18	15.56	8.36	4.19

The comparison with earlier studies of *Eucalyptus* hybrid plantations in Terai region indicates that the biomass of 2 year plantation of *Eucalyptus* hybrid was 3.2 tha^{-1} which changed to 18.5 tha^{-1} in yr-3 with 2000 trees ha $^{-1}$ (Bargali *et al.*1992). The values of present study are close to these earlier reported values (Table 3).

Table 3. Comparisons of biomass distribution in *Eucalyptus* hybrid and *Populus deltoids* plantations in terai region of India.

Vegetation	Location	Age (Years)	Density (ind/ha^{-1})	Biomas (t ha^{-1})	References
Eucalyptus hybrid	India	1	2000	0.5	Bargali*et al.* (1992)
Eucalyptus hybrid	India	2	2000	3.2	Bargali*et al.* (1992
Eucalyptus hybrid	India	3	2000	18.5	Bargali*et al.* (1992)
Eucalyptus hybrid	India	2	1830	7.18	Present study
Eucalyptus hybrid	India	3	1830	15.30	Present study
Populus deltoids	India	1	666	7.4	Lodhiyal and Lodhiyal (1997)
Populus deltoids	India	2	666	28.0	Lodhiyal and Lodhiyal (1997)
Populus deltoids	India	3	666	49.4	Lodhiyal and Lodhiyal (1997)
Mixed plantation *(D.sissoo, A.catechu and A.lebbeck*	India	4	1332	19.49	Singh *et al.* (2011)

In a young mixed 4 year old plantation of *D.sissoo, A.catechu and A.lebbeck* with density of 1332 tree ha^{-1} (Singh *et al.* 2011) have reported 4.32 t c ha^{-1}yr^{-1}carbon sequestration rate and the total vegetation biomass change from 10.86 t ha^{-1} to 19.49 t ha^{-1} in the plantation between 3rd to 4th year (Table 3). Plantations of fast growing species can play a valuable role in atmospheric carbon mitigation. The study reveals that a considerable amount of carbon is allocated in 2-3 year-old *Eucalyptus* hybrid plantation, which acts as a major carbon sink in the region as there are more than a million hectares of *Eucalyptus* hybrid plantations in the Tarai region of central Himalaya (Bargali *et al.* 1992).

Conclusion

Afforestation of *Eucalyptus* species can play an important role in carbon mitigation programmes through carbon sequestration and can reduce the pressure on existing natural forests by providing fuel, fodder, timber and other wood products. The present study highlights the significance of young plantations, which have tremendous potential of carbon sequestration.

References

Bargali SS, Singh SP, Singh RP. 1992. Structure and function of an age series of *Eucalyptus* plantation in Central Himalaya, In Dry mater dynamics. Annals of Botany **69,** 405-411.

Curtis JT, Mclntosh RP. 1950. In interrelation of certain analytic and synthetic phytosociologicalcharacter. Ecology **31,** 438-455.

FAO. 2005. Afforestation& reforestation program. Under the clean development mechanism to Kyoto Protocol Fact sheet Role

www.fao.org/forestry/site/30/18/en

IPCC. 2000. Afforestation, reforestation and deforestation activities. In: Intergovernmental Panel for Climatic Change (IPCC) (Eds.: Watson R, Noble IR, Bolin B) Chapter **3**.

Jackson ML. 1967. Soil chemical analysis. Prentice Hall of India Pvt. Ltd. New Delhi.

Jina BS, SahPankaj, Bhatt MD, Rawat YS. 2008. Estimating carbon sequestration rates and total carbon stockpile in degraded sites of oak and Pine forest of Kumaun Central Himalaya. Ecoprint**15**, 75-81.

Karky BS, Tewari A. 2007. Carbon measurement methodology and result. In: Reducing carbon emissions through community-managed forests in Himalaya (Eds.: K. Banskota, B.S.Karky and M. Skutsch). International center for integrated mountain development (ICIMOD), Kathmandu, Nepal; Chapter **4,** 39-54.

Lal R. 1999. Soil management and restoration for C sequestration to mitigate the accelerated greenhouse effect.Progress in Environmental Sciences1 **(4),** 307–326.

Lodhiyal LS, Lodhiyal N. 1997. Variation in biomass and net primary productivity in short rotation high density Central Himalayan poplar plantations. Forest Ecology and Management **98,** 167- 179.

Lodhiyal N, Lodhiyal LS, Pangtey YPS. 2002. Structure and function of Shisham forests in Central Himalaya, India: dry matter dynamics**.** Annals of Botany **89,** 41 54.

Mishra R. 1968. Ecology work book. Calcutta: Oxford and IBH Publishing.

Negi JDS, Chauhan PS. 2002. Greenhouse gases mitigation potential by Sal (*Shorearobusta*Gaertn. f.) forest in Doon Valley. Indian Forester 128**(7),** 771–778.

Pant H, Tewari A. 2014. Carbon sequestration in Chir Pine (*Pinusroxburghii*Sarg.) forests under various disturbance levels in Kumaun Central Himalaya. Journal of Forestry Research **25(2),** 401-405.

Singh V, Tewari A, Kushwaha SPS, Dadhwal VK. 2011. Formulating allometric equation for estimating biomass and carbon stock in small diameter trees. Forest Ecology and Management **261,** 1945-1949.

UNFCCC. 2010. Glossary of climate change acronyms.

Van Dijk AIJM, Keenan RJ. 2007. Planted forests and water in perspective. Forest Ecology and Management **251,** 1-9.

Walkley AJ, Black IA.1934. Estimation of soil organic carbon by chromic acid titration method. Soil Science **37,** 38–39.