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Biomass and Carbon Allocation in 8-year-old Poplar (*Populus deltoides* Marsh) Plantation in Tarai Agroforestry Systems of Central Himalaya, India

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ABSTRACT: Carbon management in forests is the global concern to mitigate the increased concentration of green house 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 great biotic pressure, industrialization, urbanization, land use changes and conversion of forests to agricultural land. Agroforestry systems 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 wood products to the farmers. Biomass and carbon allocation in Poplar agroforestry plantation in the Tarai region of central Himalaya, India have been studied and it is found that the Poplar agroforestry plantation in the Tarai region of central Himalaya had a significant amount of biomass and carbon, which acts as an additional carbon sink in the region. [New York Science Journal. 2009;2(6):49-53]. (ISSN: 1554-0200).

KEY WORDS: Biomass, Carbon, Agroforestry, *Populus deltoides*, Central Himalaya

INTRODUCTION

Carbon management in forests is the global concern to mitigate the increased concentration of green house gases in the atmosphere. It is estimated that the world's forests store 283 Gt of carbon in their biomass alone (FRA, 2005). However the global forest cover is dwindling fast in view of great biotic pressure, industrialization, urbanization, land use changes for developmental activities and conversion of forests to agricultural land. Reviving forest cover and finding low cost methods to sequester carbon is emerging as a major international policy goal (Shively *et. al*. 2004). Agroforestry is widely considered as a potential way of improving environmental and socioeconomic sustainability (Alavalapati and Nair, 2001). Agroforestry systems 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 wood products directly to the farmers on the on hand and on the other it may provide many indirect environmental benefits such as soil and water conservation, biodiversity conservation, soil nutrients enrichment etc.

India has a long tradition of agroforestry, several indigenous agroforestry systems, based on peoples needs and site-specific characteristics have been developed over the years. Agroforestry research was initiated in the country about three decades ago and several agroforestry technologies have been developed and tried on farmer's lands (Chinnamani, 1993). Poplar (*Populus deltoides)* has gained considerable importance in agroforestry plantations of Western Uttar Pradesh, Uttarakhand, Haryana, Punjab, and Jammu & Kashmir states of India, mainly due to its deciduous nature, fast growing habit and high industrial requirement (Chandra *et. al*., 2001). It has been estimated that 60,000 hectares equivalent plantations of *P.deltoides* exists in India. In the Tarai region of Indian central Himalaya Poplar was introduced on trail in 1960, and at present there are more than 16000 hectares of Poplar plantations exists in the Tarai agroforestry systems (Lodhiyal and Lodhiyal, 1997). *P.deltoides* is known for its fast growth, easy vegetative propagation and soil enrichment quality. It can be economically harvested in 6-8 years thus provide substantial wood over a short rotation. It provides valuable raw material for plywood, paper pulp, furniture, fiber board, veneer, sports goods, news print, fine paper, packing paper and match-splint industries thus makes an extra source of income to the farmers.

Comprehensive reports on biomass, productivity, structure and functioning of *P.deltoides* Tarai agroforestry platations are available (Lodhiyal *et. al*., 1992, 1995; Lodhiyal and Lodhiyal 1995, 1997). However information on carbon allocation in *P.deltoides* agroforestry plantations in this region is quite meager. Therefore the present study was designed to estimate biomass and carbon allocation in different components of 8-year-old *P. deltoides* agroforestry plantation in the Tarai region of central Himalaya.

MATERIAL AND METHODS

The present study site is located between $29^{0}3'$-$29^{0}12'$ N latitude and $79^{0}20'$-$79^{0}23'$ E longitude at an elevation of 280-300 amsl in the Tarai region of central Himalaya, India. The climate of Tarai region is sub-tropical monsoon, with a long dry season from early October to mid June. The year can be divided broadly into three seasons as summer from April to mid June, rainy from mid June to mid September, and winter from November to February. Soil is deep fertile and due to water seepage from the higher elevations the water table is high, soil moisture content is high and higher productivity (Burfal *et. al*., 2001). The Sal mixed broad-leaved forests were the natural vegetation of Tarai region (Champion and Seth, 1968). Most of these forests were converted into agricultural lands during the period of 1960s to 1980s and during this period fast growing tree species like Poplars and Eucalyptus were planted extensively in the region (Lodhiyal and Lodhiyal, 1995). The present study was conducted in a private farm at village Jawahernager in the UdhamSingh Nagar district of Uttarakhand state. At the time of present study the Poplar plantation was 8 year old and well managed under agroforestry system. To assess biomass and carbon allocation in this poplar plantation we measured trees within a sample plot of 0.25 ha and within this sample plot, diameter of all trees at breast height was measured and recorded. Mean diameter was than calculated and used in regression equation to assess tree biomass.

In order to assess the tree biomass the regression equations developed by L.S. Lodhiyal (1992) for *P.deltoides* plantation have been used. The regression equation was used in the form of:

$$Y = a + bx$$

Where, Y = Dry weight of components
x = Mean diameter at breast height (1.37 m) above the ground level (cm)
a = intercept and
b = slope

The carbon content of vegetation is surprisingly constant across a wide variety of species. Most of the information for carbon estimation described in the literature suggests that carbon constitutes between 45 to 50 percent of dry matter (Schlesinger, 1991; Chan, 1982), and it can be estimated by simply taking a fraction of biomass as (Magnussen and Reed, 2004):

$$C = 0.475 \times B$$

Where C is the carbon content and B is oven dry biomass.
In the present study we follow the above equation to assess the carbon content in different components of *P. deltoides* plantation.

RESULTS

Biomass and carbon allocation

Tree density of 8-year-old *P.deltoides* plantation was 500 trees ha^{-1} and the total tree basal area was 30.1 $m^{2}ha^{-1}$. The 8-year-old *P.deltoides* plantation had a mean dbh (diameter at breast height) of 27.69 cm. The total biomass of 8-year-old *P.deltoides* plantation was calculated 202.59 t ha^{-1}, and a single tree accounts about 0.405 t biomass. The above ground components were contributed 78.68% and below ground components were contributed 21.32% biomass to the total biomass (Table 1, Fig. 1). A total of 96.230 t C ha^{-1} was stored in the 8-year-old, short rotation *P.deltoides* plantation and by an average, a single tree accounts about 0.192 t C. Of the total carbon stored in the 8-year-old Poplar plantation, 78.68% carbon was allocated in the above ground components whereas 21.32 % carbon was allocated in the below ground components of the trees (Table 1, Fig. 2).

Table 1. Biomass and carbon allocation in different components of 8-year-old *P. deltoides* agroforestry plantation.

S.No	Components	Biomass	Carbon	Percent contribution
		$t\ ha^{-1}$	$t\ ha^{-1}$	
1	Bole wood	100.75	47.85625	49.73%
2	Bole bark	14.19	6.74025	7.00%
3	Branch	21.50	10.2125	10.61%
4	Twig	9.17	4.35575	4.53%
5	Leaf	13.80	6.555	6.81%
6	Stump root	26.18	12.4355	12.92%
7	Lateral root	14.72	6.992	7.27%
8	Fine root	2.28	1.083	1.13%
	Total	**202.59**	**96.23**	**100.00%**

DISCUSSION

The level of atmospheric CO_2 is increasing rapidly due to expanding use of fossil fuel, land use changes, deforestation and conversion of forest lands to other activities. Atmospheric level of CO_2 has increased from pre-industrial level of 280 ppm to present level of 375 ppm (Ramachandran *et. al.* 2007). Deforestation is a major anthropogenic cause of net carbon release to the atmosphere, next only to fossil fuel related emissions (Pandey, 2002). The forest ecosystems are the major biological scrubber of atmospheric CO_2 that can be significantly increased by careful management practices. However the global forest cover is declining at an alarming rate as about 13 million hectares of global forests are lost annually (FRA, 2005). In such situation of increasing atmospheric level of CO_2 and continued accelerative rate of deforestation, finding low cost methodologies to sequester increased level of atmospheric carbon into terrestrial ecosystems is a major strategy of most of the developing countries. In the Indian central Himalayan region where people's dependence on forest resources is high, agroforestry systems can play an important role in environmental and ecological sustainability. Agroforestry systems in this region can reduce the pressure on natural forests by providing the much needed fuel and fodder requirements of the peoples and can reduce a significant amount of atmospheric carbon through carbon sequestration in the standing biomass. The carbon allocation in different components of seven dominant forest types of Himalayan region have been studied by Rana *et. al.* (1989), and they have concluded that the carbon allocation in seven dominant forest types of the region ranges from 166.8 t C ha^{-1} to 440.1 t C ha^{-1}. However information on carbon allocation in *P. deltoides* agroforestry plantation in the region is not available. Our study reveals that a considerable amount of carbon allocated in 8-year-old *P.deltoides* agroforestry plantation, which acts as an additional carbon sink in the region, as there are more than 16000 hectares of Poplar plantations exits in the Tarai region of central Himalaya.

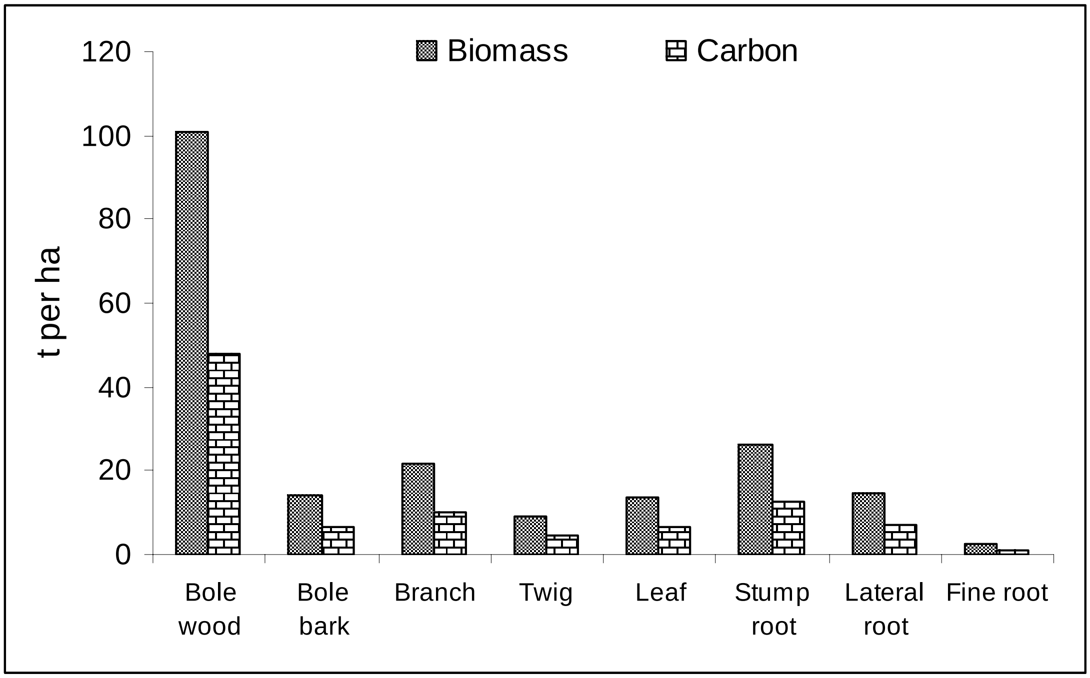

Fig 1. Biomass and carbon allocation in 8-year-old *Populus deltoides* plantation

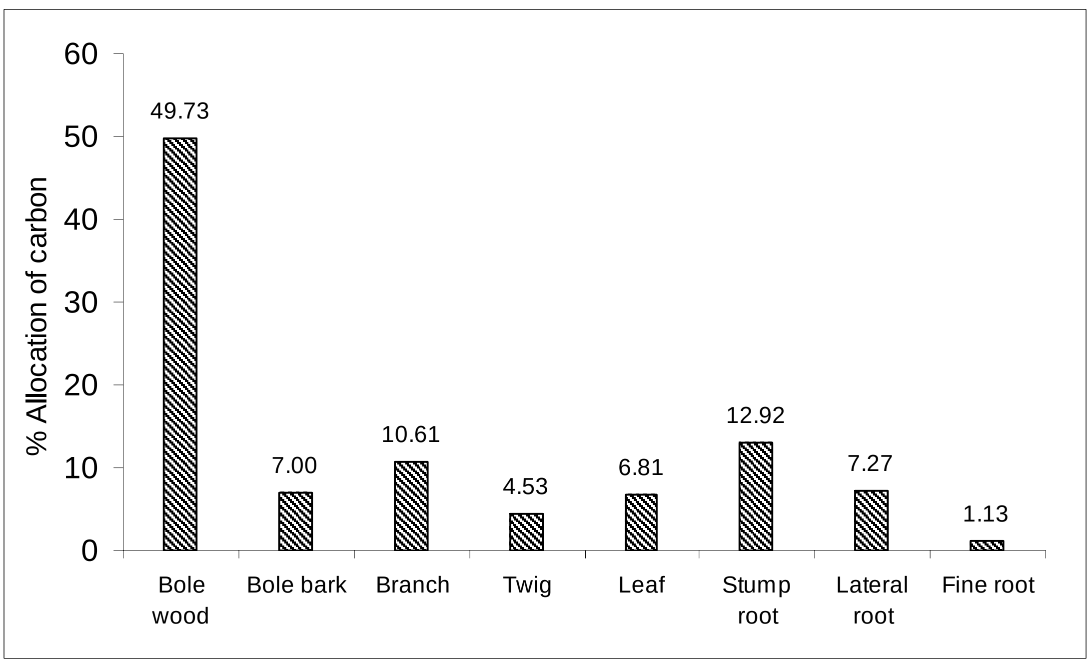

Fig 2. Percent allocation of carbon in different components of *P. deltoides* plantation.

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