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Carbon Sequestration Potential of Different Multipurpose Tree Species

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Abstract: *The present study was conducted at Dr Y S Parmar University of Horticulture and Forestry, Nauni Solan,HP,India to study the Carbon Sequestration potential of different Multipurpose tree species of Himachal Pradesh with the objective to determine the biomass of the multipurpose agroforestry tree species. Carbon sequestration potential was studied in seven species viz., Grewia optiva, Morus alba, Celtis autralis, Acer oblongum, Melia azedarach, Acacia catechu and Bauhinia variegata. The biomass carbon stock in a particular agroforestry tree species depends upon its total biomass. Carbon sequestration potential (kg/tree) of Acer oblongum, which was statistically at par with Bauhinia variegata found highest among all the species. The total biomass (kg/tree) was found highest in Acer oblongum and Bauhinia variegata among the current seven multipurpose tree species. The result of present investigation indicates that Acer oblongum and Bauhinia variegata sequestered more carbon as compared to other species, whereas low carbon was sequestered by Morus alba, Grewia optiva and Celtis australis.*

Keywords: *Agroforestry , Biomass, Carbon sequestration , Carbon Stock.*

I. Introduction

Forests plays an important role in carbon cycling, since they are large pools of carbon as well as potential carbon sinks and sources to the atmosphere. Accurate estimation of forest biomass is required for greenhouse gas inventories and terrestrial carbon accounting. The need for reporting carbon stocks and stock exchange for the Kyoto Protocol have placed additional demands for accurate surveying methods that are verifiable, specific in time and space (IPCC 2003).Agroforestry has potential to optimize biomass production and storage of that carbon fixed for long time in the wood. The amount of carbon sequestration largely depend upon the structure and function of the agroforestry system. Other factors influencing carbon storage in agroforestry systems include tree species and system management (Albrecht & Kandji 2003). It is widely believed that agroforestry holds considerable potential as a major land management alternative for conserving soil as well as maintain the soil fertility and productivity (Nair, 1992).On global basis, the productivity of Indian forest is extremely poor. Soil amelioration is not only effective, especially in salt affected wasteland in arid and semi- arid regions, but is also a method for ecological revival in terms of vegetation enrichment, soil amelioration as well as social benefits for hilly region too (Young, 1989). Carbon sequestration potential depends upon the biological productivity, which in turns depends upon interaction between species, climate, topography and management practices imposed. Thus carbon density and sequestration potential varies from place to place, which need to worked out on region to region and species to species basis. Establishment of large scale short rotation woody crop plantation has been advocated as an effective method of sequestration CO_2 and mitigating increased atmospheric CO_2 levels (House *et al*. 2002), through increasing long term C in woody biomass and in the soil . One of the most alarming issues today is the climate change brought by the increasing concentration of green house gases (GHGs) in the atmosphere . Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. The green trees have high potential of tapping atmospheric carbon through photosynthesis. The sequestrated carbon is stored in the plant tissues which results in the growth (Roger, 2012).

II. Material And Methods

The present study entitled **"**Carbon Sequestration Potential of different Multipurpose Tree Species **"** was conducted at the Experimental farm of the Department of Silviculture and Agroforestry, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh during 2013-2014. The trial was laid out in a factorial experiment in Randomized Block Design with 7 treatments viz T1 (*Acacia catechu*), T2 (*Melia azedarach*), T3 (*Grewia optiva*), T4 (*Celtis australis*), T5 (*Acer oblongum*), T6 (*Bauhinia variegata*) and T7 (*Morus alba*) . The treatments were replicated thrice, the sample plot size is 33m×33m(0.1 ha) and year of planting is 1988. Above ground biomass was estimated by non-destructive method for different plant parts viz., stem, branch, leaf and roots. To estimate biomass all the tree falling in the plot of 0.1 ha were enumerated. The diameter at breast height (dbh) was measured with calliper and height with Ravi's multimeter form height was calculated using Spiegel Relaskop to find out the tree volume using the formula given by Pressler's (1865) .

$$f = 2h1/3h$$

Where,

f = form factor
h1 =height at which diameter is half of dbh
h = total height

Volume was calculated by Pressler's formula (1865)

$$V = f \times h \times g$$

Where,

V = volume
f = form factor
h = total height
g = Basal area
$g = \pi r^2$
or $\pi (dbh/2)^2$

Where, r = radius, dbh - diameter at breast height

Specific gravity

Specific gravity was determined from the available literature. Where, the specific gravity values were not available in that case the stem cores were taken to find out specific gravity which was used further to determine the biomass of the stem using maximum moisture method (Smith, 1954).

$$Gf = \frac{Mn - Mo}{Mo} + \frac{1}{Gso}$$

Gf = Specific gravity based on gross volume
Mn = Weight of saturated volume sample
Mo = Weight of oven- dried sample
Gso = Average density of wood substances equal to 1.53

Thus the weight of wood was estimated using the formula i.e. mass per unit volume

Mass = Average specific gravity of stem wood x volume

Total numbers of branches irrespective of size were counted on each of the sample tree, then these were categorized on the basis of basal diameter into three groups, viz., < 6cm, 6-10cm, and >10 cm. Fresh weight of two sampled branches from each group was recorded separately. The formula (Chidumayo1990) was used to determine the dry weight of branches.

$$Bdwi = Btwi/1 + Mcbdi$$

Where,
Bdwi - oven dry weight of branch
Btwi - Fresh/green weight of branches
Mcbdi - Moisture content of branch on dry weight basis

Total branch biomass (Fresh/dry) per sample tree was determined as given by:

$$Bbt = n_1bw_1 + n_2bw_2 + n_3bw_3 - \sum n_ibw_i$$

Where,
Bbt - Branch biomass (fresh/dry) per tree
Ni - Number of branches in the ith branch group
Bwi - average weight of branch of ith group
I - 1, 2, 3,----------------- refers to branch group

Leaves from the branches were removed, weighed and oven dried separately to a constant weight at 80 $\pm$ 5 ^oC. The total tree biomass was the sum of stem biomass, branch biomass and leaf biomass. The tree biomass was converted into carbon fraction by a factor of 0.5 (IPCC default value).Surface litter was collected in five quadrates of 1 x 1 m^2. Samples were weighed, sub-sampled and oven dried at 65 + 5^oC to a constant weight ground and ashes. Corrected ash dry was assumed to contain 45 per cent of carbon. Below ground biomass of trees (Broad leaved) was calculated by multiplying aboveground biomass of tree with the factor 0.26 (IPCC, 2003). The data obtained were subjected to statistically analysis using RBD of experimentation as per the procedure suggested by Gome and Gomez (1984). Wherever, the effects exhibited significance at 5% level of probability, Critical difference (CD) was calculated.

III. Results And Discussion

The data presented in table 1 shows the aboveground and belowground biomass production levels of different tree species in term of stem, branch, leaf and whole tree as well as litter production. Stem biomass was found highest in *Acer oblongum* (709.26 kg/tree), which was statistically at par with *Bauhinia variegata*. Branch biomass was also found higher in *Acer oblongum* (26.37 kg/tree), which was statistically at par with *Bauhinia variegata*. Similar to stem and branch biomass, leaf biomass was also significantly recorded higher in *Acer oblongum* (4.5 kg/tree). It was statistically at par with *Morus alba, Melia azedarach, Celtis australis* and *Acacia catechu.*

TABLE 1. Biomass production levels of different agroforestry tree species (Kg/tree)

Species Components	T_1	T_2	T_3	T_4	T_5	T_6	T_7	CD $_{(0.05)}$
Above ground								
Stem	277.27	538.43	160.17	241.14	709.26	704.21	219.78	79.17
Branch	2.88	6.49	3.55	3.73	26.37	23.34	6.54	3.50
Leaf	1.20	2.10	1.43	1.27	4.50	3.83	2.37	0.92
Whole tree	**282.31**	**547.02**	**165.16**	**246.13**	**740.13**	**731.38**	**228.69**	**79.08**
Litter	0.27	0.39	0.12	0.16	0.69	0.48	0.33	0.08
Total	**282.58**	**547.41**	**165.28**	**246.29**	**740.82**	**731.86**	**229.02**	**79.11**
Below ground	70.58	136.75	41.29	61.53	185.03	182.84	57.17	19.77
Grand total	**353.16**	**684.16**	**206.57**	**307.82**	**925.86**	**914.71**	**286.19**	**98.88**

Whole tree biomass was found higher in *Acer oblongum* (740.13 Kg/tree), which was statistically at par with *Bauhinia variegata.* Litter biomass production was also significantly higher in *Acer oblongum* (0.69 Kg/tree) followed by *Bauhinia variegata, Melia azedarach and Morus alba* with their respective values of 0.48, 0.39 and 0.33 Kg/tree. *Grewia optiva* showed the minimum litter biomass, which was statistically similar to the value shown by *Celtis austratlis.* Similarly litter biomass levels were also statistically non- significant in *Melia azedarach and Morus alba.*The total aboveground biomass followed the trend almost similar to the whole tree biomass among the different tree species. It was found higher in *Acer oblongum (*740.82 kg/tree) which was statistically at par with *Bauhinia variegata.* The below ground biomass observed highest in *Acer oblongum*, which was statistically at par with *Bauhinia variegata* with their respective values of 185.03 and 182.84 kg /tree. Total above and below ground biomass was highest in *Acer oblongum* having values of (925.86 kg/tree), statistically at par *Bauhinia variegata* (914.71 kg/tree). On the other hand *Grevia optiva* (T_3) recorded lowest total biomass with a value of (206.57 kg/ha). Carbon in plant biomass from different MPTs has been termed as current carbon stock. The table 2 reveals the variability in carbon stocks, among the different MPTs. Carbon stock for total biomass was higher in *Acer oblongum (*462.93 Kg/tree), which was statistically at par with *Bauhinia variegata.* Total carbon stock kg/tree was found statistically alike in T_1, T_4, T_7 & T_3 (176.58, 153.91, 143.09 & 103.29 Kg/tree) respectively. Carbon sequestration potential kg annum^{-1} was significantly higher in T_5 (22.04 Kg annum^{-1}). It was found statistically at par with T_6 whereas it was recorded minimum in T_3 (4.49 Kg annum^{-1}).

TABLE 2. Total biomass carbon and carbon sequestration potential of different agroforestry tree species

Species	Total biomass Carbon (Kg / tree)	Carbon sequestration potential (Kg annum^{-1})
T_1 (*Acacia catechu*)	176.58	8.03
T_2 (*Melia azedarach)*	342.08	14.25
T_3 (*Grewia optiva)*	103.29	4.49
T_4 *(Celtis australis)*	153.91	7
T_5 (*Acer oblongum)*	462.93	22.04
T_6 (*Bauhinia variegata*)	457.35	21.78
T_7 (*Morus alba)*	143.09	6.50
CD 0.05	49.41	2.28

(Kg/tree and Kg annum^{-1})

IV. Conclusion

Carbon sequestration potential kg/tree found highest in *Acer oblongum* and *Bauhinia variegata* as compared to other multipurpose tree species. All the species differ significantly with each other for their biomass production level. The total biomass (kg/tree) was found highest in *Acer oblongum* and *Bauhinia variegata* among the current seven multipurpose tree species. These species should be encouraged for plantation.

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