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Carbon Sequestration Potential of Kafal (*Myrica esculenta*): An Indigenous, Multipurpose and Medicinal Tree Species in High Hills of Western Himalaya

K.K. Pandey[1], Garima Gupta[2], S.V. Mishra[3] and Deepak Maurya[4]*

[1]S.K. College of Agriculture and Research Station, IGKV, Kawardha (Kabirdham) - C.G, India
[2]Maya College of Agriculture and Technology (MCAT), Dehradun, Uttarakhand, India
[3]Indian Agricultural Research Institute (IARI), New Delhi, India
[4]WRDM Department, Indian Institute of Technology, Roorkee, Uttarakhand, India
**Corresponding author*

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ABSTRACT

A dynamic growth model (CO2FIX) has been used for estimating the Carbon Sequestration Potential of Kafal (*Myrica esculenta*), an indigenous multipurpose tree used for timber, fuel wood, fiber and in addition to its medicinal value. The present study has been carried out in the campus of V.C.S.G. College of Horticulture, U.U.H.F., Bharsar, Pauri Garhwal, Uttarakhand. The altitude of the location is ranging from longitude 78.59':20.28'E, latitude 79.00':30.05'N and 2000 m MSL altitude. The temperature and rainfall of this hilly area ranged from -4.0 to 28.0^{o}C and more than 10000 mm respectively. It is capable of thriving on snow and heavy rainfall condition. CO2FIX was parameterized for a simulation of 100 years respectively. The results indicate that the long term tree biomass accumulated was 112.59 t/ha in Biomass Carbon (Above Ground Biomass) and 71.4 t/ha in Soil Carbon (Below Ground Biomass) component respectively, at the end of simulation period assuming a tree density of 740 t/ha (approximately). The net annual carbon sequestration for Kafal over the entire simulation period was 1.839 Mg C ha^{-1} yr^{-1} (t/ha/yr).

Introduction

The Himalaya, youngest mountain range of the world covers about 18% of total geographical area of India. Forests constitute (50% of India's forest cover) an important natural resource base in the Himalaya, most important being the temperate broad leaf forests, which are largely dominated by different species of oak (*Quercus* species) (Singh and Rawat, 2012). Five species of evergreen oak namely *Quercus glauca* (phaliyant/harinj), *Q. leucotrichophora* (banj), *Q. lanuginosa* (rianj), *Q. floribunda* (tilonj/moru) and *Q. semecarpifolia* (brown/kharsu) along with Pine Deodara and Kafal grow naturally in the western Himalaya.

According to Bisht *et al.*, (2013) the dominant fodder tree species for western Himalayan region are *Quercus leucotrichophora*, *Q. floribunda* lindl, *Q. semicarpifolia*, *Myrica esculenta* (Kafal), *Aesculus indica (Himalayan chestnut), Alunus nepalensis (Utees), Pinus roxburghii (pine), Cedrus deodara (Deodara), Ficus palmata (Anjir),* *Morus alba (shahtoot), Woodforida fruticosa (kurz)* etc., and more than 250 species of herbs and shrubs in dense forest of Western Himalayan region. The most prominent species in said area for wild fruit during the summer is Kafal (*Myrica esculenta*). Therefore it was considered as species for study. It is medium size tree; having average height of 10 m and maximum of 18 m.

Kafal trees are found on hills of Nepal and Northern India, between the altitudes of one and two thousand meters above sea level. Kafal changes to reddish purple color ellipsoid-shape fruit at its maturity. In scientific journals, Kafal is mostly called *Myrica esculenta*, but also referred as *Myrica integrifolia* and *Myrica nagi*. In ancient Sanskrit language, Kafal is often called Kaiphala or Katphala and believed to have a medicinal property in its bark. The bark is yellow colored and contains the chemical substances myricetin, myricitrin and glycosides. Besides this it contains 32%. *Myrica esculenta* is a small tree or large shrub native to Hills of Nepal and northern India. Its common names include Box myrtle, Bayberry, Kafal (local name). It is a well known medicinal plant in Ayurveda i.e. Himalayan Wild Fruit – Kafal (en.wikipedia.org).

Nepali name Kaaphal or Kafal Common name - Bay-Berry, Box myrtle. Kaaphal is one of many extremely delicious wild fruits found throughout mid-Himalayan region. The fruit looks somewhat like deep-red colored raspberries. They barely have any pulp, have a big round seed in the center. Since they are very refreshing to eat, they are well liked by many Nepalese. The fresh fruits have a reputation for being a little acidic even when they are ripe, but more sour when unripe. They have a limited harvesting period and available for a short period of time only. When they were in season, local villagers picked and gathered the berries carefully from the wild growing areas and transported to Kathmandu in a wicker baskets (doko-daalo). It is not a good timber as it warps and splits badly, but is used occasionally for low-grade construction and, agricultural implements (tasteofnepal.blogspot.in).

A number of studies have reported the carbon sequestration potential (CSP) of forest and multipurpose trees in India (e.g. Dhyani *et al.*, 1996; Ravindranath *et al.*, 1997; Haripriya 2001; Lal and Singh, 2000; Swamy *et al.*, 2003; Swamy and Puri, 2005) however the published literature on assessment of carbon sequestration through the existing trees on croplands is scanty. UNFCC (United Nations Framework Convention on Climate Change) has recognized the importance of planting multipurpose trees as a greenhouse gas mitigation option, as well as the need to monitor, preserve and enhance terrestrial carbon stocks. In addition, production from plantation trees may relieve pressure on timber extraction from natural forest, and thus contribute to forest conservation

A lot of works have been done for the estimation of carbon sequestration potential of different tree species (Under forestry and Agroforestry System) but this is first attempt for wild fruit tree in Western Himalayan region of Uttarakhand for estimation of carbon sequestration potential of Kafal on per year basis and also estimated total carbon sequestered on per year and total simulation of carbon at the end of simulation period of hundred years.

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A lot of works have been done for the estimation of carbon sequestration potential of different tree species (Under forestry and Agroforestry System) but this is first attempt for Kafal tree in western Himalayan region of Uttarakhand for estimation of carbon sequestration potential of Kafal on per year basis and also estimated total carbon sequestered on per year and total simulation of carbon at the end of simulation period of 100 years.

Materials and Methods

The present study has been conducted in the V.C.S.G. College of Horticulture a campus of Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand, which is situated at logitude78.59’:20.28’E, latitude 79.00’:30.05’N and 2000 m MSL altitude. The campus spread over an area of 174.94ha; out of that area 114.3ha is mixed forest. The data has been recorded over selected area of 10 plots size 5x5 meter in different location of campus. In given plots only number of Kafal (*Myrica esculenta)* tree counted along with CBH (Circumference at Brest Height); the number of trees is approximately 1.9 i.e 740 tree/ha for the CO2FIX model.

Detail of CO2FIX

CO2FIX Model used the present study for can simulate the carbon dynamics of single species and can handle trees with varied ages. Moreover, CO2FIX outputs the biomass and C separately in above and below ground tree components cohorts wise (i.e. species wise) in addition to soil carbon dynamics. In this study, we are estimating the carbon sequestration potential of existing Kafal tree in the dense forest of western Himalayan region of Pauri district of Uttarakhand. CO2FIX v3.2 model is available free of charge for academic/research institutions (http://www.efi.int/projects/casfor/CO2FIX/register32.php). CO2FIX has been used to estimates the carbon storage and sequestration potential of selected trees species in India (Kaul *et al.,* 2010). The CO2FIX model has been tested and validated for the forest ecosystem in the Phillipines, mixed pine-oak forest of central Mexico, multi-strata AFS and tropical rainforest in Costa Rica and woodlots in Zambia (Kaonga and Smith, 2012).

Input parameters for the CO2FIX model

The main input parameters relevant to CO2FIX model are the cohort wise values for the stem-CAI (current annual increment in m^3 ha^{-1} $year^{-1}$) over years; relative growth of the foliage, branches, leaf and root with respect to the stem growth over years; turnover rates for foliage, branches and roots; and climate data of the site (annual precipitation in mm and monthly values of minimum and maximum temperatures in ^0C). Other inputs to the model includes initial surface soil organic carbon (Mg C ha^{-1}), rotation length for the tree species, per cent carbon contents in different tree parts, wood density and initial values of baseline carbon (Mg C ha^{-1}) in different tree parts, when the simulation are being carried out for the existing trees as in the present case.

Basic data required for running the CO2FIX model

For the purpose of simulating carbon stocks under Kafal forest on per ha basis, the modules taken into considerations are biomass, soil and carbon accounting modules. CO2FIX model requires primary as well as secondary data on tree (called 'cohorts' in CO2FIX terminology) for preparing the account of carbon sequestered under Kafal forest on per hectare basis. The primary data includes name of the existing tree species on forest land along with their number, diameter at breast height (DBH) (Converted by CBH). Whereas the secondary data includes the growth rates of tree biomass components (stem, branch, foliage, root) for Kafal. Accordingly, to account for the carbon sequestered under Kafal forest the basic parameters (viz. rotation length, wood density, carbon contents) set for the tree cohorts have been detailed in table 1. DBH of the surveyed plants has been used to approximately find out the age of the standing trees. To derive the incremental data of tree stem growth, the volume equations published in State Forest Report-2009 (Forest Survey of India (FSI), Dehradun, Ministry of Environment and Forests) were used as the secondary data.

Parametrization of the tree cohorts

Stem volume equations, available in Forest Survey of India Report (2009) for the Kafal has been used to generate the DBH (m) and stem volume (m^3/tree) data. This data set has been used to fit non-linear functions for stem volume–DBH relationships. This tree wise absolute stem volume–DBH relationship has then converted into hectare wise stem volume–DBH relationships, by multiplying the average number of trees found in the 10 patches. This DBH has transformed back into age to obtain hectare wise stem volume–age relationships. Ultimately, this absolute stem volume values have converted into CAI (Current Annual Increment) values of stem volume by taking the difference of current year value from preceding year value. Thus, we obtained the CAI equations for stem volume– age for the Kafal (Table 2). The relative growth data of foliage, branch and root is available for different tree species (classified under the slow, medium and fast growing categories/cohorts) at National Research Centre for Agroforestry (NRCAF), Jhansi has used to find out the relative growth of foliage, branch and root with respect to stem on slow growing and also compared by given example of CO2FIX software. These relative proportions were parameterized in CO2FIX model for branch, foliage and root growth.

Parametrization of the soil module

The climatic data of district on monthly temperature and precipitation has obtained from substation of IMD (Indian Meteorological Department), which is in the college campus and has fed as the general CAI on per tree basis for tree has been estimated from State Forest Report 2009, Forest Survey of India, Ministry of Environment and Forests, New Delhi (India). The dynamic soil carbon model YASSO describes decomposition and dynamics of soil carbon in well-drained soils.

The soil module consists of three litter compartments (non-woody, coarse-woody and fine-woody) and five decomposition compartments (extractives, cellulose, lignin like compound, humus-1 and humus- 2). Litter is produced in the biomass module through biomass turnover. For the soil carbon module, the litter is grouped as non-woody litter (foliage and fine roots), fine woody litter (branches and coarse roots) and coarse woody litter (stems and stumps). Since the biomass module makes no distinction between fine and coarse roots, root litter is separated into fine and coarse roots according to the proportion between branch litter and foliage litter.

Results and Discussion

CO2FIX simulated Kafal tree biomass/carbon stocks

The tree biomass (above and below ground) during the 100 years simulation period increased from 31.58 to 256.78Mg DM ha^{-1}. The 100 year simulation results of CO2FIX model predict that total biomass carbon (Biomass and soil carbon) would enhance to the tune of 46.59 to 230.58 Mg C ha^{-1}. Our result is on line of Subedi (2004) reported that Above Ground Biomass of *Quercus semicarpifolia* in temperate region of Nepal was ranging from 272 to 479 t/ha.

CO2FIX simulated soil carbon stocks

The estimated rate of soil carbon sequestration, though showed an increasing trend, was meager with 0.714 Mg C ha^{-1} $year^{-1}$. The soil carbon is expected to increase from 30,8 to 102.2 Mg C ha^{-1} for 100 year simulation. Similar results have been reported by Singh *et al.*, (2011) that agricultural soils of IGPs, on an average, contain 12.4–22.6 Mg ha^{-1} of organic carbon in the top 1 m soil depths.

CO2FIX simulated carbon sequestration potential (CSP) of existing Kafal forest

The CSP of existing Kafal forest has been estimated to be as 1.839 Mg C ha^{-1} $year^{-1}$ (Table 3). The CSP was also influenced by the site's climatic factors viz. monthly average temperature, total precipitation along with its distribution over different months, evapotranspiration etc. The higher CSP in this location to be attributed higher total precipitation as well as some amount of rainfall in each and every month throughout the year. Moreover, Dinajpur is situated in the foot hills, thus there is sufficient moisture in the atmosphere round the year that acts as a positive catalyst favoring enhanced C sequestration (Ajit *et al.*, 2013). These results are in line with Pathak *et al.*, (2011) that organic matter contents across soils are influenced strongly by rainfall.

Table.1 Input parameter used in CO2FIX model for simulating tree biomass components in various tree cohorts

Cohorts	Kafal Tree
No of tree ha^{-1}	740
Rotation year	100
Starting Age years estimated for 2013	28
Observed Average DBH	47
Wood density Mg DM/m^3	0.65*
Carbon content % dry weight	50
Turnover rate foliage	1.0
Turnover rate branch	0.02
Turnover rate root	0.03
Product allocation for thinning harvesting	
Stem log wood	0
Stem slash	1
Branch log wood	0
Branch slash	1
Foliage slash	1
Foliage slash soil	0.1

*Wood density record from www.fao.org.

Table.2 Current Annual Increment (CAI) of the stem volume growth m^3 ha^{-1} $year^{-1}$ over years for Kafal

Age	CAI-Vol m^3/ha/year
0	5.6670
5	8.511
10	8.912
15	10.08
20	11.7
25	13.19
30	15.56
35	18.43
40	20.95
45	24.84
50	28.21
55	33.29
60	39.01
65	43.64
70	49.99
75	56.02
80	59.82
85	63.04
90	62.97
95	60.07
100	51.94
105	39.26
110	27.57
115	10.81

CAI on per tree basis for slow, medium and fast growing trees has been estimated from State Forest Report 2009, Forest Survey of India, Ministry of Environment and Forests, New Delhi, India.

Table.3 Biomass accumulated in the Kafal tree species and carbon sequestered under Western Himalayan Region simulated using CO2FIX model

Parameters			**Observed number of existing Kafal trees 740 tree/ha in Western Himalayan region**
Tree biomass above and below ground Mg DM ha^{-1}	Baseline	Biomass	31.58
	Simulated		256.78
Soil carbon Mg C ha^{-1}	Baseline	Carbon	30.8
	Simulated		102.2
Biomass carbon Mg C ha^{-1}	Baseline	Carbon	15.79
	Simulated		128.38
Total carbon biomass + soil Mg C ha^{-1}	Baseline	Carbon	46.59
	Simulated		230.58
Net carbon sequestered of Kafal forest of Western Himalayan region over the simulated period of 100 years Mg C ha^{-1}		Carbon sequestered	183.99
Estimated annual carbon sequestration potential of Kafal forest of Western Himalayan region Mg C ha^{-1} $year^{-1}$			1.839

Lal (2004) reported that SOC concentration increased with increased rainfall in several Indian soils. Moreover, as the tree density increases the total biomass increases and hence C-sequestration rate increases. Kongs ager and Mertz, (2013) reported carbon sequestration on plantation trees and found best in rubber plantation (214 tC/ha) followed by Cocoa (65tC/ha) and Orange (76tC/ha). Nowak and Crane (2001) reported that coterminous USA currently store 700 million tonnes of carbon with a gross carbon sequestration rate of 22.8 million tC/yr on 10 cities of USA.

The estimated CSP of existing Kafal forest in Garhwal Himalayan region are encouraging, as they would add to the forest cart of C sequestration and would definitely reduce the increasing pressure on forests for timber and other commercial requirements. CO2FIX model has been used for accounting the result of Biomass (t/ha), carbon sequestration potential of Kafal on per ha basis for next 100 years.

References

Ajit, Dhyani, S.K., Ramnewaj, Handa, A.K., Prasad, R., Alam, B., Rizvi, R.H., Gupta, G., Pandey, K.K., Jain, A. and Uma. 2013. Modeling analysis of potential carbon sequestration under existing agroforestry systems in three districts of Indo-gangetic plains in India. *Agrofor Syst.*, Accepted; doi 10.1007/s10457-013-9625.

Bisht, A.S., Sharma, K.D. and Prasad, M. 2013. "*Food-Horti-Forestry Resources of Western Himalaya",* Jaya Publishing House 114-124.

Dhyani, S.K., Puri, D.N. and Narain, P. 1996. Biomass production and rooting behaviour of Eucalyptus tereticornis Sm. on deepsoils and riverbed bouldery lands of Doon Valley, India. *Indian For*, 122: 128–136

Haripriya, G.S. 2001. A frame work for carbon stored in India wood products. *Environ. Dev. Sustain*, 229–251.

http://www.fao.org/docrep/w4095e/w4095e0c.htm

http://tasteofnepal.blogspot.in/2013/05/kaaphal-or-Kafal-fruit-bay-berry.html

http://en.wikipedia.org/wiki/Myrica_esculenta

Kaonga, M.L. and Smith, T.B.P. 2012. Simulation of carbon pool changes in woodlots in eastern Zambia using CO2FIX model. *Agrofor. Syst.*, 86: 213–223 doi:10 1007/s10457-011- 9429-9.

Kongsager, R. and Mertz, J.N. 2013. The carbon sequestration potential of tree crop plantation. *Mitig. Adap. Strateg. for Global Change*, 18: 1197-1213.

Kaul, M., Mohren, G.M.J. and Dadhwal, V. K. 2010. Carbon storage and sequestration potential of selected tree species in India. *Mitig. Adapt. Strateg. Glob. Chang*., 15: 489–510.

Lal, M. and Singh, R. 2000. Carbon sequestration potential of Indian forests. *Environ. Monit. Assess.*, 60: 315–327.

Lal, M. 2004. Soil carbon sequestration in India. *Clim. Chang.*, 65: 277–296.

Nowak, D.J. and Crane, D.E. 2001. Carbon storage and sequestration by urban trees in the USA, *Environ. pollu.*, 116: 381-389.

Pathak, H., Byjesh, Chakrabarti, K. B. and Agarawal, P.K. 2011. Potential and cost of carbon sequestration in Indian agriculture: estimates from long term experiments. *Field Crop Res.*, 120: 102–111.

Ravindranath, N.H., Somashekhar, B.S., Gadgil, M. 1997. Carbon flows in Indian forest. *Clim. Chang.*, 35: 297–320.

Singh, G. and Rawat, G.S. 2012. Depletion of Oak (*Quercus* spp.) Forests in the Western Himalaya: Grazing, Fuelwood and Fodder Collection. *Global Perspectives on Sustainable Forest Management.*

Singh, H., Pathak, P.M.K., Raghubanshi, A.S. 2011. Carbon sequestration potential of Indo-gangetic agroecosystem soils. *Trop. Ecol.*, 52: 223–228.

Subedi, M.N. 2004. Above ground biomass of Quercus semecarpifolia Sm forest surveyed on natural and semi-natural stands in Nepal. *Indian Forester.*, 8: 858-866.

Swamy, S.L. and Puri, S. 2005. Biomass production and C-sequestration of Gmelina arborea in plantation and agroforestry system in India. *Agrofor. Syst.*, 64(3): 181–195.

Swamy, S.L., Puri, S. and Singh, A.K. 2003. Growth, biomass, carbon storage and nutrient distribution in Gmelina arborea in plantation and agroforestry system in India. *Agrofor. Syst.*, 64: 181–195.

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