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CARBON SEQUESTRATION IN THE SOILS UNDER SIMILAR VEGETATION GROWING IN UTTARAKHAND AND HARYANA STATES OF INDIA

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Abstract: This study was conducted for the comparison purpose with the objective to investigate the effect of similar vegetation growing in different soil conditions and environment on the soil carbon sequestration in the form of soil organic carbon stock. Under forest land use, SOC stock under chir forests growing in Uttarakhand was 61.10 t ha^{-1}, under miscellaneous forests was 58.23 t ha^{-1} and under sal forest was 58.45 t ha^{-1} while in Haryana it was 58.94 t ha^{-1} under chir, 43.55 t ha^{-1} under miscellaneous and 40.96 t ha^{-1} under sal forests. SOC stock under miscellaneous and sal forests growing in Uttarakhand was statistically significant difference with the SOC stock in similar forests growing in Haryana. Eucalyptus plantation growing in Uttarakhand was having 31.94%, khair plantation 17.98 % and shisham 41.83 % higher SOC stock as compared to similar plantations growing in Haryana. Only poplar plantation was 5.32% higher SOC stock in Haryana as compared to poplar plantations growing in Uttarakhand. SOC stock under shisham and eucalyptus plantations growing in Uttarakhand have statistically significant differences with the SOC stock under similar plantations growing in Haryana. Under horticulture land use, SOC stock under mango growing in Uttarakhand was 50.70 t ha^{-1} while growing in Haryana was having 36.25 t ha^{-1}. Organic carbon stock in soils under citrus and guava orchards in Uttarakhand was 47.55 t ha^{-1} and 40.21 t ha^{-1} and growing in Haryana was 27.41 t ha^{-1} and 29.45 t ha^{-1} respectively. SOC stock under mango, citus and guava orchards growing in Uttarakhand was statistically significant differences with SOC stock in Haryana in similar vegetation. Under agroforestry land use, sugarcane–poplar model growing in Uttarakhand was 33.48 t ha^{-1} SOC stock while similar model growing in Haryana was 25.14 t ha^{-1}. SOC stock under wheat–poplar model in Uttarakhand was 24.81 t ha^{-1} while in Haryana was 31.07 t ha^{-1} SOC stock which was statistically significant different.
Keywords: Agroforestry; Carbon sequestration; Forests; Horticulture; Soil organic carbon stock.
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INTRODUCTION

Research related to soil organic carbon has been a main focus worldwide, motivated by the potential of the soil to become a manageable sink for atmospheric carbon dioxide and thus to mitigate climate change and the known benefits of increased soil organic carbon for the functioning of soils (Mc Bratney *et al.,* 2014). Absorbing CO_2 from atmosphere and moving into the physiological system and biomass of the plants, and finally in to the soil is a practical way of removing large volume of the major green house gas (CO_2) from the atmosphere in to the biological system. Thus, the carbon is sequestered in to the plants and then from the plants to the animals. Eventually, after the death of animals, the detritus decomposed in to the soil organic carbon by microbial activities (Ramchandran *et al*., 2007). Soil organic carbon (SOC) sequestration is also defined by Olson (2013) as process of transferring CO_2 from the atmosphere into the soil of a land unit through unit plants, plant residues and other organic solids, which are stored or retained in the unit as part of the soil organic matter (humus). Retention time of sequestered carbon in the soil (terrestrial pool) can range from short-term to long-term (millennia) storage. The degradation of soils from unsustainable agriculture and other development has released billions of tons of carbon into the atmosphere. But new research shows how effective land restoration could play a major role in sequestering CO_2 and slowing climate change. Soils of the world must be part of any agenda to address climate change, as well as food and water security. There is now a general awareness of soil carbon that soil is not just a medium for plant growth (Schwartz, 2014).

The rate of carbon sequestration, the magnitude and quality of soil carbon stock depends on the complex interaction between climate, soils, tree species and chemical composition of the litter as determined by the dominant tree species (Schlesinger, 1985). The amount of SOC stored within an ecosystem, is dependent on the quantity and quality of organic matter returned to the soil matrix, the soils ability to retain organic carbon (a function of texture and cation exchange capacity), and biotic influences of both temperature and precipitation (Grace *et al*., 2005). Soil organic matter can also increase or decrease depending on numerous factors, including climate, vegetation type, nutrient availability, disturbance, and land use and management practice (Six and Jastrow, 2002; Baker, 2007). The release of nutrients from litter decomposition is a fundamental process in the internal biogeochemical cycle of an ecosystem, and decomposers recycle a large amount of carbon that was bounded in plant or tree to the atmosphere (Sevgi and Tecimen, 2008). Land use and land cover change and agricultural practices contribute about 20% of the global annual emission of carbon dioxide (IPCC, 2001). More accurate estimates of global or continental CO_2 emission from land use/ cover change can only be obtained from extrapolation of reliable local estimates (Cairns, *et al*., 1996). Therefore, comprehensive information on the spatial and temporal distribution of land use and land-cover change is a prerequisite for understanding the carbon flux. No systematic studies was conducted to estimate soil organic carbon stock by using IPCC guidelines on this aspect in this area, therefore, a study was conducted to estimated carbon sequestration in the soils in term of soil organic carbon stock under similar vegetation cover growing in Uttarakhand and Haryana states which have different climate and soil conditions.

EXPERIMENTAL

This study was conducted in whole of Uttarakhand state which forms part of the western Himalaya. It is located between 28˚43'–31˚27'N latitudes and 77˚34'–81˚02'E longitudes. The average annual rainfall of the state, as recorded is 1,547 mm. Samples were collected from all the thirteen districts *viz*. Alomra, Bageshwer, Champawat, Chamoli, Dehra Dun, Hardwar, Nainital, Pauri, Pithoragarh, Rudrapryag, Tehri, Uttarkashi and Udamsingh nagar. The state of Haryana is situated between 27°39' to 30°56'N latitude and 74°27' to 77°36'E longitude. The average rainfall is 560 mm, varying from less than 300 mm in the southwestern parts to over 1200 mm in hilly tracts of the Shivalik Hills. Soil samples were collected from all the twenty one districts *viz.* Ambala, Bhiwani, Faridabad, Fatehabad, Gurgaon, Neu, Palwal, Jhajjar, Jind, Kaithal, Karnal, Kurukshetra, Mahendragarh, Panchkula, Panipat, Rewari, Rohtak, Sirsa, Hissar, Sonipat and Yamunanagar for the study.

Since the input of organic matter is largely from aboveground litter, forest soil organic matter tends to concentrate in the upper soil horizons, with roughly half of the soil organic carbon of the top 100 cm of mineral soil being held in the upper 30 cm layer. The carbon held in the upper profile is often the most chemically decomposable, and the most directly exposed to natural and anthropogenic disturbances (IPCC, 2000). This layer is readily depleted by anthropogenic disturbances such as land use changes and cultivation. Therefore, soil organic carbon pool was estimated to the depth of 30 cm in this study.

Soil samples were collected from the similar vegetation growing in Uttarakhand and Haryana. Under forest land use, miscellaneous, sal and chir forests were growing in both the states. Under plantation land use poplar, eucalyptus, shisham and khair plantations were available in both the states. Under horticulture land use, mango, citrus and guava orchards were growing in both the states while in agroforestry land use wheat–poplar and sugarcane–poplar model were available in these states. Beside above mentioned vegetations, other types of forests, plantations, orchards agroforestry models were there but they are not common in both the states. In total, 3185 soil samples were collected from 455 sites in different land uses in Uttarakhand, including 2114 soil samples from forest; 553 soil samples from plantation; 371 soil samples from horticulture and 147 soil samples from agroforestry land uses. In Haryana, 3206 soil samples from 458 sites were collected for this study including 1309 soils samples from forests, 1120 samples from plantation land use, 686 samples from horticulture land use and 91 samples from agroforestry models. Overall results of this study are based on the analysis of 6391 soil samples, collected from both the states.

At each sampling site, 5 soil samples were collected for soil organic carbon estimation and two separate samples were collected for bulk density and coarse fragment estimation. It was ensured that sampling points typically represent the study area. Forest floor litter at each sampling point, was removed and a pit of 30 cm wide, 30 cm deep and 50 cm in length was dug out. Soil from 0 to 30 cm depth, was collected, mixed thoroughly and carried to laboratory for processing and analysis. The samples were air dried, grinded and sieved through 100 mesh sieve. The sieved sample was used for soil organic carbon estimation by standard Walkley and Black (1934) method. Bulk density of samples was estimated by standard core method (Wilde *et al*., 1964) for calculation of SOC on per unit area basis (Sakin, 2012). All the methods used in this study are in accordance to Ravindranath and Ostwald (2008). Amount of coarse fragments was estimated and deducted from the soil weight to get an accurate soil weight on per ha basis for soil organic carbon pool estimation. The data for SOC pool was calculated by using the equation as suggested by IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

RESULTS AND DISCUSSION

This study was conducted for the comparison purpose with the objective that what is the effect on soil carbon sequestration in the form of soil organic carbon stock under vegetation when similar species is growing in different soil conditions and environment. Under forest land use, SOC stock under chir forests in Uttarakhand was 61.10 t ha^{-1} while in Haryana it was 58.23 t ha^{-1} (table 1). SOC stock under chir in Uttarakhand was 4.93 % higher as compared to chir in Haryana. Under miscellaneous forests SOC stock in Uttarakhand was 58.94 t ha^{-1} and in Haryana it was 43.55 t ha^{-1} and SOC stock in Uttarakhand was 35.34 % higher as compared to Haryana miscellaneous forests. Sal growing in Uttarakhand was having 58.45 t ha^{-1} SOC stock and in Haryana it was having only 40.96 t ha^{-1}. Soils under sal growing in Uttarakhand were having 42.70 % higher organic carbon stock in comparison to the soils in Haryana. Results of one way ANOVA indicates that SOC stocks under different forests in Haryana was statistically significant differences different < 0.05 level (Variance ratio, $F = 4.472$; $p < 0.05$) while the differences in SOC stock in different forests of Uttarakhand was non-significant. SOC stock under miscellaneous and sal forests growing in Uttarakhand were showed statistically significant differences with the SOC stock under miscellaneous forests (Variance ratio, $F= 111.128$; $p <0.05$) and sal (Variance ratio, $F= 4.846$; $p <0.05$) growing in Haryana. Data indicates the SOC stocks in all the forests were higher in Uttarakhand as compared to Haryana ranging from 4.93% to 42.70%. It might be due to better accumulation of litter and microbiological activities, lower temperature and higher moisture conservation in the soils of Uttarakhand as compared to Haryana.

Table 1. Soil organic carbon stock under different vegetation in Uttarakhand and Haryana (up to 30cm)

S.No.	Vegetation	Uttarakhand		Haryana	
		SOC Stock (t ha^{-1})	SE	SOC Stock (t ha^{-1})	SE
Forests					
1.	Chir	61.10 ± 25.4641	1.00	58.23^{a} ± 23.5621	4.71

2.	Miscellaneous	58.94 ± 29.9835	1.27	43.55[b] ± 24.5124	0.83
3.	Sal	58.45 ± 26.1010	1.48	40.96[b] ± 18.1653	5.47
Plantations					
1.	Eucalyptus	46.39[a] ± 28.7777	2.14	35.16[a] ± 19.1255	0.78
2.	Khair	41.66[ab] ± 19.8177	2.95	35.31[a] ± 20.4896	2.76
3.	Shisham	37.67[bc] ± 23.4946	2.96	26.56[b] ± 13.7967	1.59
4.	Poplar	31.41[c] ± 18.3689	1.75	33.08[a] ± 13.9488	1.57
Horticulture					
1.	Mango	50.70 [a] ± 27.3877	2.07	36.23[a] ± 20.0656	1.69
2.	Citrus	47.55 [a] ± 6.9455	2.45	27.41[b] ± 14.3615	1.71
3.	Guava	40.21 [a] ± 27.6103	2.99	29.45[b] ± 14.4572	0.86
Agroforestry					
1.	Sugarcane - Poplar	33.48 ± 15.8409	4.23	25.14 ± 7.5532	1.41
2.	Wheat - Poplar	24.81 ± 12.7387	1.30	31.07 ± 12.0235	1.70
Overall					
1.	Forests	59.76[a] ± 27.3397	0.70	43.93[a] ± 24.5199	0.82
2.	Horticulture	47.27[b] ± 27.4498	1.67	31.09[bc] ± 16.5487	0.74
3.	Plantations	40.33[c] ± 25.2146	1.26	34.17[b] ± 18.4871	0.65
4.	Agroforestry	25.92[d] ± 13.4145	1.28	29.71[c] ± 11.3802	1.41

Same alphabets represent statistically at par group; ±= Standard deviation; SE= Standard Error

An increase in temperature would deplete the SOC pool in the upper layers by 28% in the humid zone, 20% in the sub-humid zone and 15% in the arid zone (Cheddadi *et al.,* 2001). Wanhong and Huang (2006) reported that the correlation analysis indicates that surface SOM concentration is in general negatively correlated with annual mean temperature. Organic matter decomposition is mainly controlled by soil moisture and decomposition rates increased with soil depth indicating greater microbial activity in the mineral soil than in the organic horizon due to greater soil moisture (Withington and Robert, 2007). Under plantation land use, soils under eucalyptus plantation growing in Uttarakhand was having maximum (46.39 t ha^{-1}) organic carbon stock among all the plantations followed by khair (41.66 t ha^{-1}), shisham (37.67 t ha^{-1}) and the least was under poplar (31.41 t ha^{-1}). In Haryana maximum SOC stock was under khair (35.31 t ha^{-1}) very closely followed by eucalyptus (35.16 t ha^{-1}), poplar (33.08 t ha^{-1}) and the least was under shisham (26.56 t ha^{-1}) (table 1). When compared the similar vegetation growing in Uttarakhand and Haryana, it was observed that eucalyptus growing in Uttarakhand was having 31.94% higher SOC stock as compared to eucalyptus growing in Haryana while khair plantation was having 17.98% higher SOC stock in Uttarakhand. Organic carbon stock in the soils under shisham plantation growing in Uttarakhand was 41.83% higher as compared to SOC stock under shisham growing in Haryana. Only poplar plantation was having 5.32% higher SOC stock in

Haryana as compared to poplar plantations in Uttarakhand. Higher SOC stock under poplar in Haryana was may be due to the better growth of poplar in Haryana, therefore higher litter fall and accumulation of more litter there. Higher SOC pool under poplar and lower pool under eucalyptus and shisham in Haryana as compared to Uttarakhand were also reported by Gupta and Pandey (2008). Relatively low temperature and higher rainfall may help in better enrichment of organic carbon in the soils of Uttarakhand as compared to Haryana. Leaf litter decomposition in tree plantations of six species including *Eucalyptus spp.* and *P. deltoides* was studied in Tarai region of Uttarakhand and upper layer of soil was found rich in organic carbon and potassium (Joshi *et al*., 1999). Results of one way ANOVA indicates that SOC stocks under different plantations in Haryana (Variance ratio, F= 8.817; p <0.05) as well as Uttarakhand (Variance ratio, F = 5.037; p <0.05) was statistically significant differences different <0.05 level. SOC stock under poplar plantation was having statistically significant differences with the SOC stock under eucalyptus (14.976*), khair (10.251*) and under eucalyptus with under shisham (8.715*) in Uttarakhand. In Haryana SOC stock under poplar was statistically significant different with SOC stock in shisham (6.519*), eucalyptus with shisham (8.597*) and khair with shisham (8.750*). SOC stock under shisham and eucalyptus growing in Uttarakhand showed statistically significant differences with the SOC stock under eucalyptus (Variance ratio, F= 36.816; p <0.05), shisham (Variance ratio, F= 11.888; p <0.05) growing in Haryana.

Under horticulture land use, SOC stock under mango growing in Uttarakhand was 50.70 t ha^{-1} while growing in Haryana was having 36.25 t ha^{-1}. Organic carbon stock in the soils under citrus and guava growing in Uttarakhand was 47.55 t ha^{-1} and 40.21 t ha^{-1} and growing in Haryana was 27.41 t ha^{-1} and 29.45 t ha^{-1} respectively. SOC stock under mango, citrus and guava growing in Uttarakhand was 39.94 %, 73.48 % and 36.54 % higher as compared to under mango, citrus and guava growing in Haryana respectively. In general, mean increase in SOC stock in Uttarakhand was 52.04% higher in comparison to Haryana in horticulture land use. Results of one - way ANOVA indicates that SOC stocks under different orchards in Haryana (Variance ratio, F= 10.244; p <0.05) as well as Uttarakhand (Variance ratio, F= 4.279; p <0.05) was statistically significant differences different < 0.05 level. SOC stock under mango orchards was having statistically significant differences with the SOC stock under guava (10.448*) in Uttarakhand. In Haryana SOC stock under mango orchards was statistically significant different with SOC stock in citrus (8.824*) and under guava (6.784*). SOC stock under mango, citus and guava orchards growing in Uttarakhand was statistically significant differences with the SOC stock under mango (Variance ratio, F= 27.308; p <0.05), citrus (Variance ratio, F= 15.190; p <0.05) and guava orchards (Variance ratio, F = 22.396; p < 0.05) growing in Haryana.

Under agroforestry land use, sugarcane–poplar model growing in Uttarakhand was having 33.48 t ha^{-1} SOC stock while similar model growing in Haryana was having 25.14 t ha^{-1}. In Haryana this model was having 33.17 % lesser SOC stock in comparison to Uttarakhand. SOC stock under wheat – poplar model in Uttarakhand was 24.81 t ha^{-1} and in Haryana this model was having 31.07 t ha^{-1} SOC stock. There was 25.23 % hike in the SOC stock under wheat – poplar model growing in Haryana as compared to Uttarakhand. Overall, SOC stock in agroforestry land use was 14.62% higher in Haryana as compared to Uttarakhand. SOC stock under agroforestry in Uttarakhand was 25.92 t ha^{-1} while in Haryana it was 29.71 t ha^{-1}. Results of one - way ANOVA indicates that SOC stocks under different agroforestry models in Uttarakhand (Variance ratio, F= 5.308; p <0.05) was statistically significant differences different at < 0.05 level. SOC stock under wheat - poplar model growing in Uttarakhand and Haryana was statistically significant different (Variance ratio, F= 8.242; p <0.05). SOC stock contribution of different vegetation cover (when land uses were integrated) was worked out and depicted in Fig. 1. Contribution of chir was maximum (13.79% in Haryana and 11.48% in Uttarakhand), followed by miscellaneous forests (11.07 % in Uttarakhand and 10.32% in Haryana, sal (10.98 % in Uttarakhand and 9.70% in Haryana) and the least contribution was in Uttarakhand was of wheat–poplar model (4.66%) and sugarcane–poplar model (5.96%) in Haryana. When it was worked out land use wise, it was observed that in Uttarakhand, maximum contribution was of forests (33.53%) followed by plantation (29.52%),

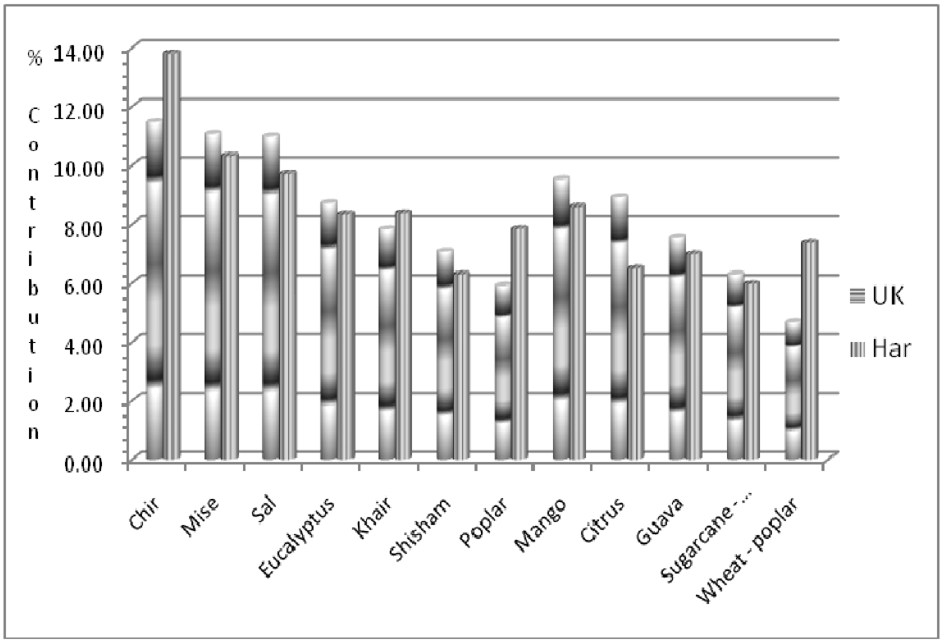

Figure 1. Contribution SOC Stock of different vegetations when land uses Integrated

horticulture (26.01%) and the least were of agroforestry (10.95%). In Haryana, maximum contribution was also of forests (33.81%), followed by plantation (30.82%), horticulture (22.05%) and the least were from agroforestry (13.32%).

Over all, SOC stock under forests in Uttarakhand was 59.76 t ha^{-1} while similar types of forests in Haryana was having 43.93 t ha^{-1} which was about 36.03 % higher in Uttarakhand. Under plantations growing in Uttarakhand, average SOC stock was 40.33 t ha^{-1} while similar plantations growing in Haryana was having 34. 17 t ha^{-1} which was 18.08 % less as compared to Uttarakhand. Average SOC stock under horticulture land use in Uttarakhand was 47.27 t ha^{-1} and in Haryana, it was 31.09 t ha^{-1} which was 52.04 % higher in Uttarakhand under similar vegetations. Under agroforestry land use, SOC stock in Uttarakhand was 25.92 t ha^{-1} while in Haryana it was 29.71 t ha^{-1} which was 14.62 higher as compared to Uttarakhand. Results of one way ANOVA indicates that SOC stocks under different forests in Haryana (Variance ratio, F= 54.799; $p < 0.05$) as well as Uttarakhand (Variance ratio, F= 105.242; $p < 0.05$) was statistically significant differences at <0.05 level. SOC stock under forests was having statistically significant differences with the SOC stock under plantation (19.432*), horticulture (12.490*), agroforestry (33.845*) in Uttarakhand. In Haryana SOC stock under forest was statistically significant different with SOC stock in plantation (9.761*), horticulture (12.834*) and under agroforestry (14.223*). The differences in SOC stock under these forests in Uttarakhand and Haryana was statistically significant (Variance ratio, F= 203.023; $p < 0.05$). The differences in SOC stock under these plantations in Uttarakhand and Haryana was statistically significant (Variance ratio, F= 23.034; $p < 0.05$). The differences in SOC stock under orchards in Uttarakhand and Haryana was statistically significant (Variance ratio, F= 102.323; $p < 0.05$). SOC stock in different land uses were different and higher carbon sequestration was under forests followed by plantation, horticulture. Since every land-use change causes a disturbance of the long-termed adjusted balance of soil organic matter (SOM) supply and mineralization, self-restoration also leads to alterations in the SOM dynamics (Olga, 2010). Most changes in land use, affect the amount of carbon held in vegetation and soil, thereby, either it releasing carbon dioxide (a greenhouse gas) to, or removing it from the atmosphere (Kim *et al*., 2005). Plants and particularly trees, because of their large biomass per unit area of land, continue to make an important contribution to the global carbon cycle. While deforestation is estimated to have released an additional 1.6 GtC per year into the atmosphere during the 1990s, terrestrial vegetation is believed to have absorbed between 2 and 3 GtC per year at the same time. Any soil disturbance associated with forest management may release carbon to the atmosphere, and should be minimised to optimise soil carbon stocks (Broadmeadow and Mathew, 2003). The highest SOC content was found in natural undisturbed forest, whereas lowest SOC was observed in conventionally- tilled, continuously-cropped plots. Studies conducted by Anikwe *et al*., (2003) and Lal (2002) showed that tillage adversely affects carbon storage in the soil. These results show that conventional tillage reduces soil carbon stocks when compared to other management practices. Agroforestry land use has minimum SOC stock in both the states as agriculture land due to ploughing whole field; accelerate the chances to escape the CO_2 in to the atmosphere. In many areas, agricultural and other land use activities have upset the natural balance in the soil carbon cycle, contributing to an alarming increase in carbon release (Schlesinger, 1999; Schlesinger and Lichter, 2001). Conversion of natural to agricultural ecosystems causes depletion of the SOC pool by as much as 60% in soils of temperate regions and 75% or more in cultivated soils of the tropics. The depletion is exacerbated when the output of C exceeds the input and when soil degradation is severe. Some soils have lost as much as 20 to 80 tons C/ha, mostly emitted into the atmosphere (Lal, 2004). An estimate of the release of carbon from terrestrial ecosystems as a result of land use/cover change in low latitude forests is estimated at 1.65 ± 0.4 Pg C yr^{-1}, due to the modification of high biomass forest ecosystems to systems of lower biomass such as secondary and degraded forests, cultivated land and pastures (Lugo *et al*., 1996; Dixon *et al*., 1986).

SOC stock in the soils of Uttarakhand was higher as compared to Haryana. It might be due to better environment for carbon sequestration in low temperature, higher moisture, and better microbial activities there. Soils under arid and semi–arid climates irrespective of physiographic regions are impoverished in SOC despite their ability to interact with organic matter in binding OC in terms of clay–organic complex. Sequestration of OC in soils of these climates is not possible due to high temperature and less rainfall impairing the fate of vegetative cover over the land. Relatively low rainfall and high summer temperature have been found to be the main reason for poor SOC Content (Tieszen, 2000). Chapman and Thurlow (1998) also observed that rise in mean annual temperature of 5°C could potentially increase CO_2 emission by a factor of 2 to 4. It is estimated that 1°C increase in temperature could lead to a loss of 10% of soil organic carbon in the regions of the world with annual mean temperature of 5°C (Miko and Kirschbaum, 1995). While in the regions having a mean temperature of 30°C, 1°C increase in temperature would lead to 3% loss of soil organic carbon. Soil carbon density generally increases with increasing precipitation, and there is an increase in soil carbon with decreasing temperature for any particular level of precipitation (Post *et al.,* 1982). Mellilo *et al*., (2002) observed that soil warming accelerate the soil organic matter decay and carbon dioxide fluxes to the atmosphere.

CONCLUSION

This study indicates that soil organic carbon stock was different under the similar vegetation growing in different climatic conditions *viz.* Uttarakhand and Haryana state. SOC stock under chir, sal, miscellaneous forests, eucalyptus, shisham and khair plantations and mango, citrus and guava orchards was higher in Uttarakhand in comparison to Haryana. Differences in SOC stocks under similar vegetation growing in different states were statistically significant differences. Quantitative evaluation of the impact of vegetations on the soil is necessary because it will give the wholesome information about the enrichment of soil due to a particular tree species. This information will be helpful to the researchers and forest managers to formulate suitable afforestation strategies.

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