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STATUS OF SEQUESTERED ORGANIC CARBON IN THE SOILS UNDER DIFFERENT LAND USES IN SOUTHERN REGION OF HARYANA

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Abstract: Soil organic carbon (SOC) was estimated in 1141 samples collected from different land uses *viz.* forests, block plantations, horticulture, agroforestry and agriculture in Faridabad, Gurgaon, Mahendragarh, Mewat, Palwal and Rewari districts of southern region of Haryana. The maximum SOC stock was under forests (37.61 t ha^{-1}), followed by horticulture (27.26 t ha^{-1}), plantation (27.96 t ha^{-1}), agriculture (17.72 t ha^{-1}) and agroforestry land use (10.84 t ha^{-1}). One - way ANOVA revealed that SOC stock under different land uses was significantly different. In plantation land use, organic carbon stock in the soils under *Azadirachta indica* (neem) was maximum, followed by eucalyptus spp., *Ailanthus excelsa* (maharukh), mixed plantation, *Dalbergia sissoo* (shisham), *Holoptelia integrifolia* (papri) , *Pongamia pinnata* (karanj) and *Acacia catechu* (khair). Statistically SOC stocks under different plantations were significantly different. Amongst orchards, the maximum SOC stock was under C*itrus lemonum* (lemon) and the minimum under *Aegle marmelos* (bel). In agroforestry land uses, *A. excelsa–Gossypium herbaceum* (kapas) model contained highest amount of SOC whereas the *Cicer arietinum* (Chana) – *Acacia tortilis* (Israeli babool) stored minimum amount of SOC. The mitigation potential calculation revealed that soils under forests can sequester three times and plantations and horticulture land uses can hold more than double organic carbon as compared to agroforestry land use. In case of plantations, the *A.indica* and eucalyptus plantation can store more than three time SOC stock as compared to *A. catechu* while *A. excelsa*, mixed and *D. sissoo* can hold more than double SOC stock in comparison to *A. catechu*. Within orchards species, *C. lemonum* can hold more than double SOC stock as compared to *A. marmelos* while Mangifera indica, *Ziziphus mauritiana* and *P.guajava* orchards can hold nearly one and half time more SOC stock in comparison to *A. marmelos*.

Keywords: Soil Organic Carbon, Forest, Orchard, Tree Plantation, Agriculture, Agro-Forestry, Southern Haryana.

Introduction

Soil organic carbon is a very important attribute not only from the soil fertility point of view but also as the carbon sink. Carbon sequestration is defined as the biotic process whereby the atmospheric CO_2 is transferred into a long lived C pool and stored securely so that it is not

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immediately re-emitted. The strategy of soil C sequestration is cost-effective and environmentally friendly [1]. The soil organic carbon (SOC) pool is about 2.6 times the biotic pool [2, 3] and twice the atmospheric pool. There is some concern that the increase in global temperature may result in a long term loss of SOC [4]. Mellilo *et al*., (2002) [5] observed that soil warming accelerates the soil organic matter decay and carbon dioxide fluxes to the atmosphere. Hence, SOC pool plays an important role in climate change processes by acting either as source or sink of atmospheric CO_2. It has been postulated that increasing soil organic matter (SOM) concentrations, by 5–15% in soils up to 2 m depth, could decrease atmospheric CO_2 concentrations by 16–30% [6, 7]. It is because of these multifarious functions that led Albrecht (1938) [8] to observe that ‘‘Soil organic matter (SOM) is one of our most important national resources; it's unwise exploitation has been devastating; and it must be given its proper rank in any conservation policy.’’ The Intergovernmental Panel on Climate Change (IPCC) identified creation and strengthening of carbon sinks in the soil as a clear option for increasing the removal of CO_2 from the atmosphere and has recognized soil organic carbon pool as one of the five major carbon pools for the land use, land use change in Forestry sector (paragraph 21 of the annex to draft decision 16/CMP.1) [9].

Knowledge of SOC stocks and changes would help us device plans for appropriate management of soils to increase SOC levels to increase productivity and sustainability of agricultural, forest and grassland systems; the sustainable management of ecosystem; the mitigation of GHG emissions and also to study the likely impact of climate change on soils / ecosystems in the future [10].

These ideas have led to substantial attention being paid to quantifying the stocks of C in soils, and the mechanisms of stabilizing C in soils, including land management options, to increase SOM stocks [11, 12]). The most prudent approach to study SOC, however, would be on a unit area basis for a specified depth interval which requires information on the spatial distribution of soil types, SOC and bulk density of soils. It would thus provide a better understanding of the terrestrial reservoir of SOC far beyond the general objectives of C sequestration in soils and the detrimental effects of global warming [3].

No systematic study has been undertaken to estimate the soil organic carbon in forests as well as in other land uses in southern region of Haryana by following standard and uniform methodology for field and laboratory work**.** Therefore, this study was undertaken in Southern region of Haryana comprising Faridabad, Gurgaon, Mahendragarh, Mewat, Palwal and

Rewari districts to estimate SOC stock under different land uses *viz.* forests, block plantations, horticulture, agroforestry and agriculture as per the IPCC guidelines.

Materials and Methods

Topsoil is very sensitive to human disturbance under the changing climate. Estimates of topsoil SOC pool may be crucial for understanding soil carbon dynamics under human land uses and soil potential of mitigating the increasing atmospheric CO_2 by soil C sequestration [13]. SOC is concentrated in the upper 30cm of the soil. Thus it is readily depleted by anthropogenic (human-induced) disturbances such as land-use changes and cultivation [14,15]. The soil organic carbon stock therefore, was estimated up to the depth of 30 cm in this study.

Study Area: Study was conducted in southern region of Haryana comprising Faridabad, Gurgaon, Mahendragarh, Mewat, Palwal and Rewari districts in five land uses *viz.* forests, plantations, horticulture, agriculture and agroforestry. Under forests land use, soil organic carbon stock was estimated in miscellaneous forests because no other kind of forest occurs in this region. Under plantation land use SOC stock was estimated in Eucalyptus spp., Shisham (*Dalbergia sissoo*), Maharukh (*Ailanthus excelsa)*, Papri (*Holoptelia integrifolia*), Neem (*Azadirachta indica*), Karanj (*Pongamia pinnata),* Khair (*Acacia catechu*) and mixed plantation. Under horticulture land use SOC was estimated in Guava (*Psidium guajava*), Mango (*Mangifera indica*), Aonla+ Aloe (*Emblica officinalis+Aloe barbadensis*), Kinnow (*Citrus reticulata*), Shahtoot (*Morus alba*), Bel (*Aegle marmelos*), Lemon (C*itrus lemonum*), Phalsa (*Grewia asiatica*) and Ber (*Ziziphus mauritiana*) orchards. SOC was also estimated under agroforestry *viz.* Shisham – Bajra (*Pennisetum glaucum*), Maharukh (*Ailanthus excelsa)*– Kapas (*Gossypium herbaceum*), Israeli babul (*A.tortilis)* – Wheat (*Triticum sativum*), Maharukh – Chana (*Cicer arietinum*), Maharukh – Mustard (*Brassica juncea)*, Khair - Wheat and Wheat – Babul (*Acacia nilotica*) models.

Soil Sample Collection: The number of soil samples collected from all the land uses in southern Haryana was 1141. In each district, three forest ranges were selected and in each range, three blocks were selected randomly. Therefore, statistically, two stage sampling was done in which first stage unit *i.e.* forest range was selected and second stage unit *i.e.* sampling sites randomly selected in three blocks of each range. At each sampling site, 5 soil samples for soil organic carbon estimation and two separate samples for bulk density and coarse fragment estimation were collected. It was ensured that sampling points typically represent the study area. Variation in the number of samples was due to difference in area available under particular land uses.

Latitude, Longitude and altitude of each sampling site were recorded by GPS. Forest floor litter of an area of 0.5m x 0.5 m, 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, from three sides of the pit, was scraped with the help of Kurpee and the soil was mixed thoroughly and brought to laboratory for analysis. Details of the sites from where soil samples were collected and the numbers of sample collected are presented in Table 1 and sampling points are depicted in Fig. 1.

Table 1. Details of the sites under all land uses in Southern Region of Haryana

Sl. No.	Vegetation Cover	Altitude (m)	Area Covered (Forest Range)	No. of samples Collected
Forest Land Use				
1	Miscellaneous	176 - 370	Rewari, Bawal, Nahar, Faridabad, Ballabagarh, Gurgaon, Helamandi, Sohana, Mahendragarh, Narnaul, Chaudhari, Nuh, Punhana, Firozpur, Palwal and Hodal	329
Plantation Land Use			**Village**	
1.	Eucalyptus	176 - 300	Palawag, Jhabua, Pali, Tigaon, Chhanisa, Dayalpur, Dhankot, Bhodsai, Sohana,Ghasera, Nuh, Patakjur, Punhana, Nagina, Naseerbas, Mandkaula, Hodal, Hasanpur, Manpur, Hamirpur, Palwal	147
2.	Shisham	217 - 254	Dharuhera, Palawag, Kanina	21
3.	Maharukh	212 - 267	Khel, Bawal, Dhamdama, Pathaudi	28
4.	Papri	219 - 330	Majra, Jhabua, Nahar, Palwag, Kanti	35
5.	Mixed	180 - 298	Rewari, Khel,Palawag, Gurgaon, Bhagan, Helamandi, Karia, Rattan Kalan, Malab	63
6.	Neem	186 - 253	Subana, Rewari, Bhopani	21
7.	Karanj	225	Jeetpura	7
8.	Khair	270 - 326	Madhogarh, Karia	14
Horticulture land use				
1.	Ber	180 - 341	Dewana, Jeevra, Nuh, Bhinakhi	28
2.	Aonla + Aloe	227	Kanarwas	7
3.	Shahtoot	245	Bawal	7
4.	Guava	183 - 250	Berriyabagh, Majari, Kheriroad, Tehirsauf, Sultanpur, Pataudi, Bhorakalan, Damdama, Ghasera, Hodal, Chanat	77
5.	Phalsa	255	Bawal	7

6.	Kinnow	306	Arokodh	7
7.	Bel	254	Bawal	7
8.	Lemon	248	Lalpur	7
9.	Mango	185 - 195	Dhauj, Chhanisa, Kitwari	21
Agroforestry Land use				
1.	Shisham - Bajra	235 - 254	Bawal, Asadpur	14
2.	Maharukh - Kapas	214	Tumbri	7
	Israeli babool - Wheat	297 - 307	Duloth, Kantibas, Shadpur, Krisnavati	28
	Israeli babool - Gram	353	Nizampur	7
	Israeli babool - Mustard	262 - 343	Karia, Bhojabas, Budhwal, Sirohi Nagal	28
	Babool - Wheat	242	Nangal	7
	Khair - Wheat	332	Madhogarh	7
Agriculture land use				
1	Agriculture	171 - 280	Karanewas, Bawal, Nagalmandi, Rewari, Jadra, Kahina, Gudha, Jhagaauli, Mahendragarh, Pali, Manger, Dauj, Pali, Faridabad, Bondhbari, Patadui, Manser, Damdama, Sohana, Punhana, Nagina, Naseerbas, Patakjur and Malab, Rupanka, Kot, Hathin	210
			Total samples Collected	**1,141**

Laboratory Analysis: The samples were air dried, grinded and sieved through 100 mesh sieve (2 mm sieve). The sieved samples were used for soil organic carbon estimation by standard Walkley & Black (1934) method [16]. Amount of coarse fragments were estimated in each sample and deducted from the soil weight to get an accurate soil weight on hectare basis and used for soil organic carbon calculation. Bulk density of every site was estimated by standard core method [17]. All the methods used in this study are in accordance to Ravindranath, and Ostwald, (2008) [18].

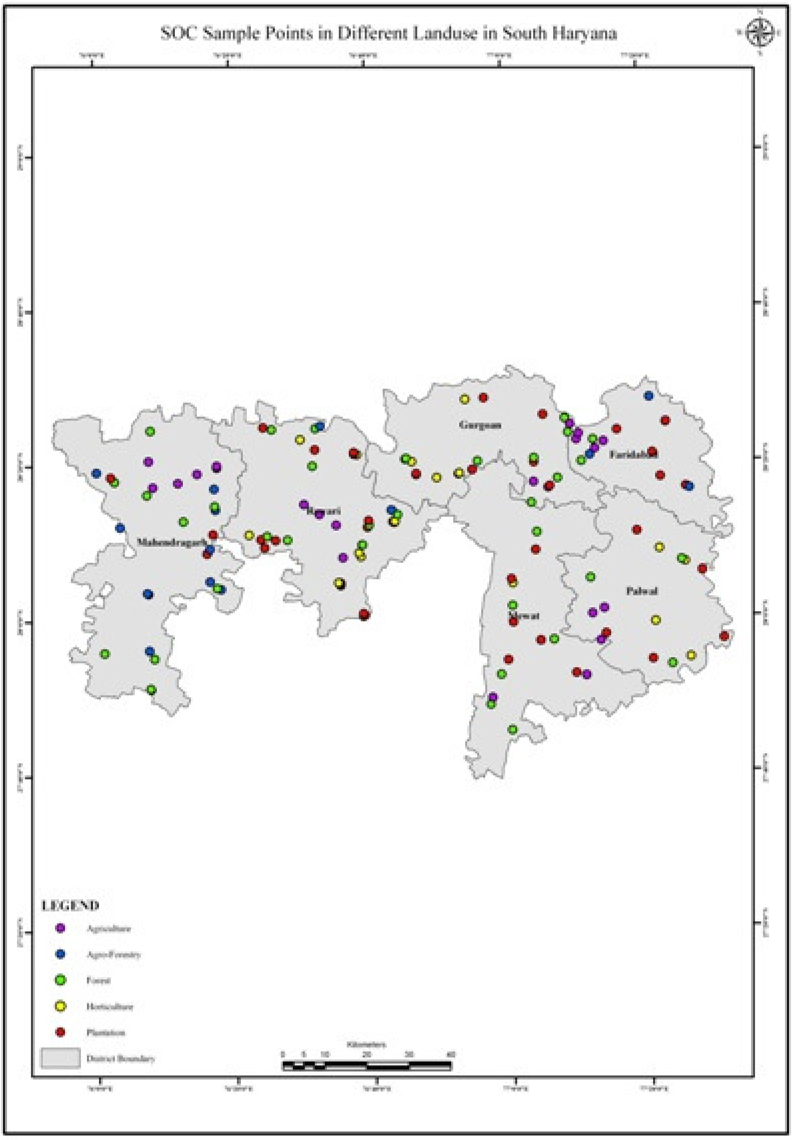

Fig. 1. Sampling points in Southern Region of Haryana

The data for SOC stock was calculated by using the following equation as suggested by IPCC Good Practice Guidance for LULUCF [19]:

Equation for SOC:

$$SOC = \sum_{Horizon=1}^{Horizon=n} SOC_{horizon}$$

$$= \sum_{Horizon=1}^{Horizon=n} ([SOC] * Bulk\ density * depth * (1 - C\ frag) * 10)_{horizon}$$

Where,

SOC = Representative soil organic carbon content for the forest type and soil of interest, tones C $ha.^{-1}$

$SOC_{horizon}$ = Soil organic carbon content for a constituent soil horizon, tones C ha^{-1}

[SOC] = Concentration of SOC in a given soil mass obtained from analysis, g C (kg $soil)^{-1}$

Bulk density = Soil mass per sample volume, tones soil m^{-3} (equivalent to Mg m^{-3})

Depth = Horizon depth or thickness of soil layer, m

C Fragment = % volume of coarse fragments / 100, dimensionless

Results and Discussion

Landuse –wise SOC Stock

Soil organic carbon stock under different land uses in southern region of Haryana was estimated and results are presented in Table 2. Under forest land use, only miscellaneous forest was found to occur and the SOC under this forest was 37.60 t ha^{-1}. Under plantation land use, the organic carbon stock in the soils under neem was maximum (35.48 t ha^{-1}) followed by eucalyptus (33.16 t ha^{-1}), maharukh (24.70 t ha^{-1}), mixed (22.76 t ha^{-1}), shisham (22.38 t ha^{-1}), papri (19.14 t ha^{-1}), karanj (17.61 t ha^{-1}) and khair (10.75 t ha^{-1}). Statistically SOC stocks under different plantations were significantly different. Subset for $\alpha = 0.05$ indicates that neem plantation stands separately (a), while eucalyptus was statistically at par with neem as well as maharukh hence placed with both (ab). Mixed and shisham plantation were placed in subset (c) and khair was placed separately (d). However, papri and karanj were statistically at par with both shisham and khair therefore, placed with both (cd). Soils under neem plantation contained 7.00 %, 43.64 %, 55.82 %, 58.53 % and 230.05 higher organic carbon stock as compared to eucalyptus, maharukh, mixed, shisham and khair plantations, respectively. SOC stock under eucalyptus plantation was 34.25 %, 45.63 %, 48.17 % and 208.47 % higher as compared to maharukh, mixed, shisham and khair plantations, respectively. SOC stock under shisham plantation was 22.77 t/ha in Haryana and similar results were reported by Gupta and Pandey (2008) [20]. 39.06 t/ha SOC stock under eucalyptus plantation and 28.12 t/ha in shisham plantation of Hardwar district of Uttarakhand as reported by Gupta (2011) [21] corroborates the above findings. Similar results for eucalyptus plantations in Udhamsingh nagar (Uttarakhand) has also been reported by Gupta and Sharma (2012) [22]. SOC stock under mixed plantation was marginally (1.71 %) higher as compared to shisham plantation while it was 111.81 % higher as compared to khair plantation. Mitigation potential of different plantations was worked out against khair which has the lowest SOC stock. It was found that neem and eucalyptus plantation can store more than three time SOC stock as compared to the khair while maharukh, mixed and shisham can hold more than double SOC stock in comparison to khair. Standard error varies from 1.10 to 4.27 which is below 5.00 and indicates the low variation in the data under plantations.

Under horticulture land use mainly lemon, ber, aonla + aloe, guava, mango, phalsa, shahtoot, bel and kinnow orchards were available in southern region of Haryana. Maximum SOC stock was observed under lemon (38.92 t ha^{-1}), followed by mango (33.11 t ha^{-1}), ber (29.28 t ha^{-1}), aonla + aloe (27.74 t ha^{-1}), guava (27.70 t ha^{-1}), kinnow (21.90 t ha^{-1}), phalsa (21.74 t ha^{-1}), shahtoot (21.08 t ha^{-1}) and the minimum SOC stock was under bel orchards (18.55 t ha^{-1}). Soils under lemon orchards stored 17.54 %, 32.96 %, 40.54 % and 109.87 % higher organic carbon stock as compared to mango, ber, guava and bel orchards, respectively, while SOC stock under mango orchards was higher by 13.11 %, 19.57 %, 51.23 % and 78.54 % in comparison to ber, guava, kinnow and bel orchards, respectively. Organic carbon stock in the soils under guava was 49.33 % higher as compared to kinnow. The variation in SOC stocks under different orchards was statistically non significant. 40.62 t/ha SOC stock under mango orchards and 29.46 t/ha in guava orchards in Hardwar district of Uttarakhand was reported by Gupta (2011) [21]. 40.12 t/ha SOC stock under mango orchards in Udhamsingh nagar (Uttarakhand) has also been reported by Gupta and Sharma (2012) [22]. Mitigation potential indicates that lemon orchards can hold more than double SOC stock as compared to bel while mango, ber and guava orchards can hold nearly one and half time more SOC stock in comparison to bel orchards.

In agroforestry land uses, maximum SOC stock was observed under maharukh – kapas model (21.68 t ha^{-1}), followed by shisham – bajra (13.56 t ha^{-1}), mustard – israeli babool model (11.19 t ha^{-1}), wheat – khair (9.51 t ha^{-1}), wheat – israeli babool (8.91 t ha^{-1}), wheat – babul (6.81 t ha^{-1}) and the least SOC stock was under gram – israeli babool (6.22 t ha^{-1}). SOC stocks under different agroforestry model were statistically significantly different. Subset for $\alpha = 0.05$ indicates that in agroforestry landuse the maharukh – kapas stands separately (a), shisham – bajra stands separately (b), and gram – israeli babool stands separately (c), while mustard – israeli babool, wheat – khair, wheat – israeli babool, wheat – babul was statistically at par with shisham – bajra as well.

Table 2. Soil Organic Carbon Stock under different Land uses in Southern Region of Haryana (up to 30 cm)

Sl. No.	Vegetation Cover	SOC Stock (t ha^{-1})	SD	Mitigation Potential (Land use wise)	S E
Forest Land Use					
1	Miscellaneous	37.60	± 20.6182	--	1.34
Plantation Land Use					
1.	Neem	35.48^{a}	± 16.5656	3.30	4.27
2.	Eucalyptus	33.16^{ab}	± 13.6866	3.08	1.33
3.	Maharukh	24.70^{bc}	± 11.6241	2.30	2.60
4.	Mixed	22.77^{c}	± 13.0198	2.19	1.94
5.	Shisham	22.38^{c}	± 12.1603	2.08	3.14
6.	Papri	19.14^{cd}	± 12.9760	1.78	2.59
7.	Karanj	17.61^{cd}	± 6.7579	1.63	3.02
8.	Khair	10.75^{d}	± 3.4817	1.00	1.10
Horticulture land use					
1.	Lemon	38.93	± 4.7137	2.09	2.10
2.	Mango	33.12	± 18.7222	1.78	4.83
3.	Ber	29.28	± 13.5323	1.58	3.02
4.	Aonla + Aloe	27.74	± 5.5077	1.49	2.46
5.	Guava	27.70	± 14.5025	1.49	1.95
6.	Kinnow	21.90	± 10.2411	1.18	4.58
7.	Phalsa	21.74	± 6.0217	1.15	2.69
8.	Shahtoot	21.08	± 6.1511	1.13	2.75
9.	Bel	18.55	± 16.3317	1.00	7.30
Agroforestry Land use					
1.	Maharukh - Kapas	21.69^{a}	± 4.6636	3.48	2.08
2.	Shisham - Bajra	13.57^{b}	± 5.2037	2.18	1.65
3.	Mustard – Israeli babool	11.19^{bc}	± 6.8100	1.80	1.52
4.	Wheat - Khair	9.52^{bc}	± 3.5804	1.53	1.60
5.	Wheat – Israeli babool	8.91^{bc}	± 6.3200	1.43	1.41
6.	Wheat - Babul	6.81^{bc}	± 4.3124	1.09	1.93
7.	Gram - Israeli babool	6.22^{c}	± 2.4362	1.00	1.08
Over all					
1.	Forests	37.60^{a}	± 20.6182	3.47	1.34
2.	Plantation	27.26^{b}	± 14.5585	2.51	0.94
3.	Horticulture	27.96^{b}	± 14.1516	2.57	1.29
4.	Agriculture	17.72^{c}	± 8.1310	1.63	0.66
5.	Agroforestry	10.84^{d}	± 6.6559	1.00	0.79

Same alphabets represent statistically at par group

as gram – israeli babool hence placed with both (bc). Mitigation potential of maharukh – kapas can hold SOC stock more than three times as compared to gram – israeli babool model.

SOC stock under maharukh – kapas model was 59.84 %, 127.84 % and 143.43 % higher as compared to shisham – bajra, wheat – khair and wheat – israeli babool model, respectively. SOC stock under wheat - khair model was higher (6.85 %) as compared to wheat – israeli babool model. Standard error varied from 1.08 for gram - israeli babool model to 2.08 for maharukh – kapas model which indicates the low variability in the data.

When SOC stock under different land uses were tested by one - way ANOVA, it was found that SOC stock under all land uses were significantly different (Variance ratio, F = 62.573; p = < 0.05) (Table 3). SOC stock under forest was significantly different from the SOC stock under plantation, agroforestry, agriculture and horticulture. SOC stock under plantation was significantly different from the SOC stock under agriculture and agroforestry (Table 3). Further, the SOC stock between the different plantations was significantly different at 0.05 level (Variance ratio, F = 9.09; p = < 0.05). SOC stock under neem was significantly different from the SOC stock under all plantations except eucalyptus. SOC stock under eucalyptus and khair was also significantly different from SOC under all plantations. Organic carbon stocks in the soils in different models under agroforestry land use were statistically significantly different at < 0.05 level (Variance ratio, F = 4.638; p = < 0.05).

Table 3. Statistically significant mean differences on the basis of CD (LSD)

Sl No.	Vegetation	Mean Difference	P value
1	Forest Vs Plantation	10.3493*	0.000
2	Forest Vs Horticulture	9.6434*	0.000
3	Forest Vs Agroforestry	26.7683*	0.000
4	Forest Vs Agriculture	19.8878*	0.000
6	Plantation Vs Agriculture	9.5385*	0.000
8	Plantation Vs Agroforestry	16.4190*	0.000
9	Horticulture Vs Agriculture	10.2444*	0.000
10	Horticulture Vs Agroforestry	17.1249*	0.000
11	Agriculture Vs Agroforestry	6.8801*	0.002

* *Mean difference is significant at the 0.05 level*

SOC stock under maharukh – kapas was significantly different from SOC stock in all other models while SOC stock in shisham – bajra model was significantly different from SOC stock in wheat – israeli babool, wheat – babul and gram - israeli babool models.

Share of SOC stock occupied by different land uses in southern region was worked out (Fig.2). Maximum share was occupied by forest (30.89 %) followed by horticulture (23.03 %), plantation (22.46 %), agriculture (14.60 %) and the minimum share was occupied by agroforestry (8.93 %).

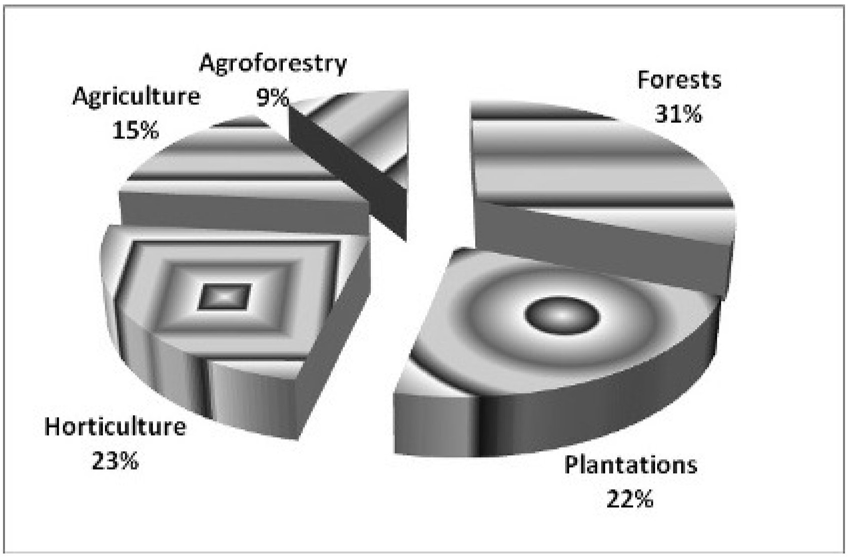

Fig. 2. Contribution of different land uses towards SOC stock

Over all, in southern region of Haryana, maximum SOC stock was under forests (37.61 t ha^{-1}) followed by horticulture (27.26 t ha^{-1}), plantation (27.96 t ha^{-1}), agriculture (17.72 t ha^{-1}) and agroforestry land use (10.84 t ha^{-1}). Subset for $\alpha = 0.05$ indicate that forest stands separately (a), plantation and horticulture were statistically at par therefore, grouped together (b) while agriculture stands separately (c) and agroforestry also stands separately (d). SOC stock under forests was 37.97 %, 34.51 %, 112.25 % and 246.96 % higher as compared to plantation, horticulture, agriculture and agroforestry landuse, respectively. Organic carbon stock in the soils under plantation was 53.84 % higher as compared to agriculture while it was 151.48 % higher as compared to agroforestry landuse. SOC stock under horticulture land use was marginally higher as compared to plantation land uses (2.50 %) while it was 57.79 % and 157.93 % higher as compared to agriculture and agroforestry land use respectively. SOC stock under agriculture was 63.47 % higher as compared to agroforestry land use. Mitigation potential indicated that soils under forests can sequester three times and plantations and horticulture land uses can hold more than double organic carbon as compared to agroforestry land use.

Soils under forest contained higher organic carbon than under other land uses. The forest litter layer was the main component for carbon increase [23]. Managing the forests may be useful practice to increase soil carbon status because the presence of trees affects carbon dynamics directly as well as indirectly. Forest soils are one of the major carbon sinks on earth, because of their higher organic matter content [24]. Soils can act as sinks or as a source for carbon in the atmosphere depending on the changes happening to soil organic matter. Equilibrium between the rate of decomposition and rate of supply of organic matter is disturbed when forests are cleared and land use is changed [25, 26]. Higher litter input and fine root biomass may partly contribute to the greater SOC in the forest [27].

District-wise SOC Stock:

Total organic carbon stocks in the soils under forests in six districts of the southern region of Haryana was calculated as 1.24 million tons (Table 4). Out of this stock, Gurgaon district contained 30.65 per cent (382849.23 t), followed by 28.72 per cent in Faridabad (358817.87 t), Rewari 14.85 per cent (185559.74 t), Mewat 9.66 per cent (120728.64 t), Palwal 8.91 per cent (111316.75 t) and the minimum SOC stock was found in Mahendragarh district i.e. 90028.44 t which is 7.21 per cent of total stock of SOC in forest of southern region of Haryana. The variation in amount of SOC stock in different districts is mainly due to difference in the extent of forest cover of the districts. The total SOC stock in southern region *i.e.* 1.24 m t is equivalent to 4.58 million tons of CO_2 sequestered in these soils. The build-up of each tons of soil organic matter removes 3.667 tons of CO_2 from the atmosphere [28]. Enhancement of forest area and increasing the SOC stocks in these soils is a very important tool of removing CO_2 from the atmosphere.

Table 4. District wise SOC Stock under Forest in Central Region of Haryana (up to 30 cm)

Sl. No.	District	Area (ha)	SOC Pool (tons)	Per cent of total stock in Forest in S R of Haryana
1	Faridabad	6931	358817.87	28.72
2	Gurgaon	8889	382849.23	30.65
3	Mahendragarh	5727	90028.44	7.21
4	Mewat	3216	120728.64	9.66
5	Palwal	2225	111316.75	8.91
6	Rewari	5102	185559.74	14.85
	Total in Southern region of Haryana	**32,090**	**12,49,301 or 1.24 million tons**	**100.00**

Total SOC stocks under horticulture in study area was 2,32,434.78 tons (Table 5). Out of these, Mewat district had the maximum SOC stock (62973.54 t, which is 27.09 per cent of total stock of horticulture land use study area), followed by Mahendragarh.

Table 5. District wise SOC stock under Horticulture land uses Southern Region of Haryana (up to 30 cm)

Sl. No.	District	Area (ha)	SOC Pool (tons)	Per cent of total stock in Horticulture in S R of Haryana
1	Faridabad	778	25782.92	11.09
2	Gurgaon	954	25729.38	11.07
3	Mahendragarh	1978	59043.30	25.40
4	Mewat	2438	62973.54	27.09
5	Palwal	1138	42993.64	18.50
6	Rewari	680	15912.00	6.85
	Total in Central region of Haryana	**7,966**	**2,32,434.78**	**100.00**

(59043.30 t, which is 25.40 per cent), Palwal (42993.64 t, which is 18.50 per cent), Faridabad (25782.92 t, which is 11.09 per cent), Gurgaon (25729.38 t, which is 11.07 per cent) and Rewari district (15912.00 t, which is 6.85 per cent of total stock of horticulture land use in study area). The total SOC stock in orchards of southern region *i.e.* 2,32,434.78 t is equivalent to 8,52,338.34 t of CO_2 sequestered in these soils. It evident from the data that Mewat is the most prominent district in southern region of Haryana as far as SOC stock and horticulture land use is concerned.

SOC Stock in National Park and Wildlife Sanctuary:

In southern region of Haryana, Sultanpur National Park is situated in Gurgaon district and Nahar Wildlif Sanctuary in Rewari district. The organic carbon stock was higher (Table 6) in the soils under Nahar Wildlife Sanctuary (12300.22 tons) than that in Sultanpur National Park (6138.17 tons). Total soil organic carbon stock in wildlife sanctuaries and national park situated was 18438.39 tons and it is equivalent to 67613.78 tons of CO_2 sequestered in these soils.

Table 6. SOC stock under different Wild life Sanctuary in Central Region in Haryana (up to 30 cm)

Sl. No.	Name	Area (ha)	SOC Stock (tons)	Per cent of total SOC Stock
Under National park and Wildlife Sanctuaries				
1	Sultanpur National Park, Gurgaon	142.52	6138.17	33.29
2	Nahar Wildlife Sanctuary, Rewari	211.34	12300.22	66.71
	Total	**353.86**	**18,438.39**	**100.00**
	Equivalent to CO_2 Sequestered		***67,613.78 t***	

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