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Seasonal Assessment of Biomass and Carbon Sequestration of Herbaceous Vegetation and Litter Layer in Homegarden Agroforestry System of Sam Higginbottom University of Agriculture, Technology and Sciences Campus, Prayagraj, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

An increase in greenhouse gases (GHGs) in the atmosphere, such as CO_2, is what drives global warming. Strong carbon management is the first step in helping to stop climate change, safeguard human health, and create profitable businesses. A key strategy for lowering greenhouse gases emissions is carbon capture and storage. The study aimed to investigate the carbon sequestration potential of the herbaceous vegetation and litter layer in home garden agroforestry systems during

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the rainy season, winter season, and summer seasons in the SHUATS (Sam Higginbottom University of Agriculture, Technology and Sciences) Campus, Prayagraj. The total dry weight of the herbaceous layer and litter layer was measured, and the corresponding carbon sequestration values were calculated. During the rainy season, the herbaceous layer exhibited a total dry weight ranging from 0.31 kg m^{-2} to 0.36 kg m^{-2}, resulting in carbon sequestration values ranging from 1.83 Mg C ha-1 to 2.13 Mg C ha-1. The litter layer had a total dry weight ranging from 0.13 kg m^{-2} to 0.16 kg m^{-2}, contributing to carbon sequestration values ranging from 0.76 Mg C ha-1 to 0.92 Mg C ha-1.In the winter season, the herbaceous layer demonstrated a total dry weight ranging from 0.22 kg m-2 to 0.28 kg m-2, resulting in carbon sequestration values ranging from 1.29 Mg C ha-1 to 1.65 Mg C ha-1. Similarly, the litter layer exhibited a total dry weight ranging from 0.18 kg m-2 to 0.216 kg m-2, contributing to carbon sequestration values ranging from 1.05 Mg C ha-1 to 1.25 Mg C ha-1.During the summer season, the herbaceous layer displayed a total dry weight ranging from 0.303 kg m-2 to 0.361 kg m-2, resulting in carbon sequestration values ranging from 1.76 Mg C ha-1 to 2.10 Mg C ha-1. The litter layer had a total dry weight ranging from 0.16 kg m-2 to 0.24 kg m-2, contributing to carbon sequestration values ranging from 1.00 Mg C ha-1 to 1.32 Mg C ha^{-1}. The results indicate that the herbaceous layer and litter layer of home garden agroforestry systems in the SHUATS Campus, Prayagraj, have the potential to sequester significant amounts of carbon during different seasons. This highlights the importance of home gardens in mitigating climate change and promoting sustainable land management practices.

Keywords: Carbon Sequestration; Greenhouse Gases (GHGs); herbaceous vegetation; litter layer; home garden agroforestry; rainy season; winter season; summer season.

1. INTRODUCTION

Carbon dioxide, a trace gas found in Earth's atmosphere, is necessary for photosynthesis, the greenhouse effect, and the marine carbon cycle. One of the many greenhouse gases that are in the earth's atmosphere is this one. Carbon appears throughout life in numerous ways, it is a chemical element, just like hydrogen or nitrogen, and an essential component of biomolecules. It exists on Earth as a solid, dissolved substance, or gas. For instance, gaseous carbon dioxide (CO_2) is created when carbon and oxygen interact; this chemical is also present in graphite and diamond. Life as we know it would not exist without the presence of carbon. The oceans have 48,000 Gt of the planet's total carbon, of which 39,000 Gt are in the seas. Only 6,000 Gt of fossil C, the second-largest deposit, is available. Furthermore, the amount of terrestrial carbon (C) stored in the world's forests, plants, and soils is only 2500 Gt, as opposed to the 800 Gt in the atmosphere. As a result of human activity, the normal movement of carbon compounds between the atmosphere, the oceans, and terrestrial ecosystems is currently being changed. The annual emissions from the use of fossil fuels, including the manufacture of cement, are 6.3 Gt of carbon dioxide, of which 2.3 Gt is taken up by the seas, 0.7 Gt is used by terrestrial ecosystems, and 3.3 Gt is added to the atmosphere (Hairiah et al. 2009).

Two major issues that humans are currently facing the loss of biodiversity and rising atmospheric CO_2 levels both eventually result in a change in the planet's climate [1,2]. An increase in greenhouse gases (GHGs) in the atmosphere, such as CO_2, is what drives global warming. Strong carbon management is the first step in helping to stop climate change, safeguard human health, and create profitable businesses. A key strategy for lowering GHG emissions is carbon capture and storage. One technique that researchers use to postpone the effects of climate change is learning how to absorb and store carbon dioxide. The significance of this approach in the fight against climate change is becoming more widely acknowledged by the scientific community.

Sequestration is a method used to remove greenhouse gases from the atmosphere (Sreejesh, 2016). As a result of learning about the many advantages of agroforestry, the Indian government released an ambitious National Agroforestry Policy in 2014 to encourage planting trees on farms. To increase smallholder farmers' productivity, income, and standard of life, the strategy aims to integrate diverse agroforestry-focused policies, initiatives, and groups. When India presented the National Agroforestry plan (NAP) at the World Agroforestry Congress in Delhi in February 2014, it became the first country in the world to adopt a full agroforestry plan. Agroforestry has been recognized as a promising tactic in addressing the problem since storing carbon in plants is a practical method to reduce greenhouse gas emissions in the atmosphere [3].

Gifawesen et al. [4] estimate that the agriculture sector is currently to blame for 25% of the world's greenhouse gas emissions. Home gardens are commonly defined as a land use system that involves the deliberate management of multipurpose trees and shrubs, along with annual and perennial agricultural crops, and typically livestock, within the compounds of individual houses. In this system, the entire tree crop and animal unit are intensively managed by family labor [5]. Home gardens retain greater amounts of carbon in both above and below ground biomass and soils compared to other agricultural systems, although they generally have lower carbon levels than mature woods (Schroth et al., 2011; Mattsson et al., 2013).

Home gardens are considered to be climate-smart, tree-crop integrated, subsistence-level agricultural systems that are resistant to extreme climatic hazards, which is consistent with our findings [4]. In order to lower atmospheric CO_2 and lessen the effects of climate change, tree-based agroforestry hastens the process of atmospheric carbon sequestration (Wilson and Lovell, 2016). Trees absorb carbon dioxide through the biological process of photosynthesis and store it as carbon in their trunks, branches, leaves, and roots. Furthermore, soil serves as a significant carbon sink in forests due to the fact that it stores carbon. Natural forests, plantations, agroforestry techniques, and a number of other activities all serve as biomass and carbon dioxide (CO_2) sinks via photosynthesis [6]. Standing biomass from plants, such as wood, and underground plant roots are two examples of long-living carbon pools where the carbon that plants accumulate during photosynthesis is stored. It seems reasonable that larger plants sequester more carbon since biomass is where plants store carbon. Because of this, adding trees to agricultural landscapes will unquestionably improve the capacity of agricultural systems to store carbon [7].

Biomass is the term used to describe the entire mass of all organic stuff, both living and dead. When an area's biomass is taken into account it is expressed in kg per unit area, and when a specific tree is mentioned, it is stated in kg per tree [8]. Carbon makes up approximately about half of plant biomass. The most straightforward and accurate pool to measure in agroforestry trees is the above-ground tree carbon pool [9]. Deforestation and degradation have a direct impact on this pool. The challenge to quantify belowground biomass of trees is a significant additional carbon sink. The root-to-shoot ratio is often used to gauge belowground root biomass since there is a continuous relationship between the two types of biomass. Standing subterranean vegetation, shrubs, herbs, and cover crops are a few types of herbaceous and understory vegetation that absorb carbon. In sample plots, this pool is classified as damaging. According to Collins et al. [10] and the entire carbon cycle, the dynamics of soil organic carbon (SOC) are crucial for the long-term productivity of ecosystems. Nair et al. [11] reviewed soil carbon sequestration (SCS) in agroforestry in comparison to other land-use systems, noting a general trend of rising soil organic carbon (SOC), an indicator of soil carbon sequestration (SCS), in agroforestry and ranking the various land-use systems according to their soil organic carbon (SOC) content in the following order: forests > agroforests > tree plantations > arable crops. In Indian soils, the total SOC pool is thought to be 21 Pg to a depth of 30 cm and 63 Pg to a depth of 150 cm. Lal [12] estimates that the SOC pool in Indian soils makes up 2.2% of the global pool at 1 m of depth and 2.6% at 2 m. Lal [12]. According to Davis et al. [13], a variety of factors, including species richness, plantation age, management rigor, spacing, and cropping type, affect the ability of plantation crops to store carbon. Long-term Carbon sequestration Potential (CSP) increases are a result of slower-growing species' wood having a higher specific gravity [14].

Due to their excellent ability to adapt to and mitigate climate change as well as their role in lowering household food security and nutrition due to rising food prices [15,16,17], agroforestry systems have recently attracted increased attention. Since agroforestry systems may retain agricultural output while also capturing carbon, they are an effective alternative for environmental management [18,1,2]. Establishing links between protected forests, preserving watershed hydrology, conserving soil, increasing farm income, ensuring food security and stable land tenure in developing countries, and restoring and maintaining biodiversity are some of the secondary benefits that could result [19]. The difficulty with agroforestry systems is preserving the benefits of various tree species while minimizing the negative effects of crop competition [20].

Home gardens are traditional agroforestry systems that contribute significantly to local biodiversity conservation and provide various ecosystem services. This study focuses on evaluating the biomass and carbon sequestration of home garden Agroforestry system of the SHUATS Campus in Prayagraj, during the rainy season, winter season, and summer seasons aiming to understand their ecological significance.

2. MATERIALS AND METHODS

The direct method involving sampling area i.e., as mentioned above (Home Garden Agroforestry system in SHUATS Campus, Prayagraj), and also based on secondary data.

Study Area: The proposed research project was conducted in the home gardens of Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS) campus in Prayagraj (Allahabad), Uttar Pradesh, during 2021–2022. The SHUATS campus area were taken for data collection to estimate the biodiversity, biomass and carbon sequestration of homegardens in three different seasons ie., Rainy (Kharif)- July to October, Winter (Rabi)- November to Feburary, and Summer (Zaid) - March to June. A Total of 24 Sites are used for taking measurements, in Six areas (Plots) i.e., Yeshu Darbar Campus area North, Yeshu Darbar Campus area South, Yeshu Darbar Campus area East, Chapel Campus area North, Chapel Campus area South, Intermediate College area. From each area four sites were selected for estimation.

Climate: In the South-East of the U.P., has a subtropical climate with both seasonal temperature extremes—winter and summer—predominates. In extremely cold winters, it can get as cold as 32°F in December and January, while in extremely hot summers, it can get as hot as 115°F in May and June. Frost in the winter and sweltering summer winds are also frequent. The annual average rainfall is about 1013.4 millimeters, with the rainiest months being July through September and the winter months seeing sporadic showers.

Topography: The district is part of the alluvial plain of the central Ganga. The district's two most significant rivers are the Ganga and the Yamuna. The holy Ganga and Yamuna confluence in the middle of the district at Allahabad and flow in the shape of the "Y" alphabet, dividing the district into three physiographic tracts, namely the Trans-Ganga region, Doab region, and Trans-Yamuna region. Other rivers that flow in the district and at the end meet with Ganga or Yamuna are Tonnes and Belan.

Methodology: The herbaceous vegetation and litter layer samples were collected from five subplots (quadrats of 1m x 1m size) in four cardinal directions North, East, South, West and at the center in each main plot at a distance of 1m from the outside boundary of the main plot. From these five subplots, herbaceous material (<5cm diameter) and litter layer was sampled using an aluminum/wooden square frame of 1m x 1m. For collection of samples destructive sampling method (Harvest the aboveground biomass of each sampled plant, separating leaves, stems, and flowers) is used. For collection of litter layer select the litter sampling points within each garden. Collect the surface litter material from each sampling point by systematically sampling in area. Remove any non-litter materials (e.g., rocks, twigs) from the collected litter samples. Each of the herbaceous material and litter samples was weighed using a digital scale and recorded. The samples were mixed well and subsamples of 100g each were taken for moisture content determination. The samples collected were subjected to oven drying to determine the biomass of the samples. Oven drying was set at 65-70ºC and was observed for at least 48 hours or until the samples reach their stable weight. Oven-dry weight of subsamples were noted to compute for the total dry weights using the formula [21]:

$$\text{Total Dry Weight } (kg\ m^{-2}) = \frac{\text{Total Fresh Weight (kg)} \times \text{Subsample Dry Weight } (g)}{\text{Subsample Fresh Weight } (g) \times \text{Sample Area } (m^2)}$$

Further, each sample was powdered (milled) using a grinding machine and a 0.5gm sieved sample was weighed for ashing. This was done by burning the sample (0.5gm sieved sample) in muffle furnace at 550℃ for 5 hours until a white ash was obtained for carbon content analysis [22,23,24]. Finally, the ash content and carbon fraction were calculated using following equation.

$$\text{Ash\%} = \frac{\text{W3} - \text{W1}}{\text{W2} - \text{W1}} \text{ X } 100$$

$$CF\ \% = (100 - ash\ \%) \times 0.58$$

(Where; W1 = weight of crucible; W2 = weight of oven dried plant samples + empty crucible weight; W3 = weight of ash + empty crucible weight; CF = carbon fraction and 0.58 is a conversion factor).

Carbon storage in herbaceous vegetation and litter layer was estimated using the formula (Lasco *et al*., 2006):

Carbon Sequestration/Carbon Density in Herbaceous Vegetation and Litter ($Mg\ C\ ha^{-1}$) = Total Dry Weight ($Mg\ ha^{-1}$) × Carbon Conc. %

Where; Total Dry Weight = Mg/ ha; Carbon Conc. (%) = gram C/ 100g biomass.

Data Analysis: Calculate the average biomass and carbon content for each herb species and litter across all home gardens. Calculate the total biomass and carbon sequestration potential of herbs and litter for each home garden and the entire sample. To analyze the data statistically and identify significant differences between herb species, garden sizes, or management practices, use appropriate statistical methods such as t-tests or ANOVA. These tests can help determine if there are significant differences in biomass and carbon content between different herb species and in litter layer, or management practices. The data averaged into respective parameter requisite was subjected to suitable transformation. After analysis, data was accommodated in the table as per the needs of objectives for interpretation of results. The interpretation of data was done by using the critical difference value calculated at 0.05 probability level. The level of significance was expressed at 0.05 probabilities. The F-test was used to determine the significant difference.

3. RESULTS AND DISCUSSION

1. Carbon sequestration of herbaceous vegetation and litter layer of home gardens during rainy season (Kharif- July to October)

Total dry weight and Carbon density of herbaceous Layer and litter layer in home gardens during Rainy season of SHUATS Campus, Prayagraj.

Table 1 depicts the data relevant to the calculation of carbon sequestration of herbaceous vegetation and litter layer in homegardens across selected areas of the SHUATS Campus, Prayagraj in Rainy Season (Kharif)- July to October For the herbaceous vegetation the highest total dry weight was observed in Intermediate College (0.36 kg m^{-2}) followed by Yeshu Darbar South (0.35kg m^{-2}) Chapel South (0.34kg m^{-2}) Yeshu Darbar North (0.33 kg m^{-2}) Chapel North (0.32 kg m^{-2}) Yeshu Darbar east (0.31 kg m^{-2}). For litter layer the highest total dry weight value was observed in Chapel North (0.161 kg m^{-2}) followed by Intermediate College (0.150 kg m^{-2}), Chapel South (0.146 kg m^{-2}), Yeshu Darbar South (0.142 kg m^{-2}), Yeshu Darbar North (0.133 kg m^{-2}) Yeshu Darbar east (0.130 kg m^{-2}). Results revealed that highest carbon density of herbaceous layer were observed in Intermediate College (2.13 Mg C ha^{-1}) followed by Yeshu Darbar South (2.06Mg C ha^{-1}) Chapel South (1.98 Mg C ha^{-1}) Yeshu Darbar North (1.92 Mg C ha^{-1}) Chapel North (1.89 Mg C ha^{-1}) and Yeshu Darbar east (1.83 Mg C ha^{-1}). For the litter layer the highest carbon density was observed in Chapel North (0.92 Mg C ha^{-1}) followed by Intermediate College (0.87 Mg C ha^{-1}), Chapel South (0.84 Mg C ha^{-1}), Yeshu Darbar South (0.82 Mg C ha^{-1}), Yeshu Darbar North (0.77 Mg C ha^{-1}), Yeshu Darbar east (0.76 Mg C ha^{-1}). Similar findings were also reported by [25]. These variations are because of factors such as vegetation type, climate, and management practices.

2. Carbon sequestration of herbaceous vegetation and litter layer of homegardens during winter season (Rabi- November to Feburary)

Total dry weight and Carbon density of herbaceous vegetation and litter layer in home gardens during winter season of SHUATS Campus, Prayagraj.

Table 2 depicts the data relevant to the calculation of carbon sequestration of herbaceous vegetation and litter layer in homegardens across selected areas of the SHUATS Campus, Prayagraj in Winter Season (Rabi)- November to Feburary.

The highest total dry weight value of herbaceous vegetation was observed in Intermediate College (0.28 kg m^{-2}) followed by Yeshu Darbar South (0.26 kg m^{-2}) Chapel South (0.25 kg m^{-2}) Yeshu Darbar North (0.24 kg m^{-2}) Chapel North (0.23 kg m^{-2}) Yeshu Darbar east (0.22 kg m^{-2}).For the litter Layer the highest total dry weight value was observed in Chapel North (0.216 kg m^{-2}) followed by Chapel South (0.209 kg m^{-2}), Intermediate College (0.205 kg m^{-2}), Yeshu Darbar North (0.195 kg m^{-2}), Yeshu Darbar South (0.191 kg m^{-2}) Yeshu Darbar east (0.183 kg m^{-2}). Results revealed that highest carbon density of herbaceous vegetation were observed in Intermediate College (1.65Mg C ha^{-1}) followed by Yeshu Darbar South (1.53 Mg C ha^{-1}) Chapel South (1.42 Mg C ha^{-1}) Yeshu Darbar North (1.39 Mg C ha^{-1}) Chapel North (1.31 Mg C ha^{-1}) and Yeshu Darbar east (1.29 Mg C ha^{-1}) and for Litter layer the highest carbon density were observed in Chapel North (1.25 Mg C ha^{-1}) followed by Chapel South (1.21 Mg C ha^{-1}), Chapel South (1.190Mg C ha^{-1}), Yeshu Darbar North (1.13Mg C ha^{-1}), Yeshu Darbar South (1.10 Mg C ha^{-1}), Yeshu Darbar east (1.05 Mg C ha^{-1}). These findings are similar to [25].

Table 1. Total dry weight and Carbon Sequestration of Herbaceous vegetation and Litter Layer of Home Garden Agroforestry System during Rainy Season in SHUATS Campus, Prayagraj

Plots	Total dry weight of herbaceous layer (kg m^{-2})	Carbon Sequestration of herbaceous (Mg C ha^{-1})	Total dry weight of litter layer (kg m^{-2})	Carbon Sequestration of litter (Mg C ha^{-1})
Yeshu Darbar North	0.33	1.92	0.133	0.77
Yeshu Darbar South	0.35	2.06	0.142	0.82
Yeshu Darbar East	0.31	1.83	0.130	0.76
Chapel North	0.32	1.89	0.161	0.92
Chapel South	0.34	1.98	0.146	0.84
Intermediate College	0.36	2.13	0.150	0.87
F-test	**S**	**S**	**S**	**S**
CD@5%	0.019	0.011	0.016	0.009
SE(m)	0.006	0.004	0.005	0.003
SE(d)	0.009	0.005	0.007	0.004

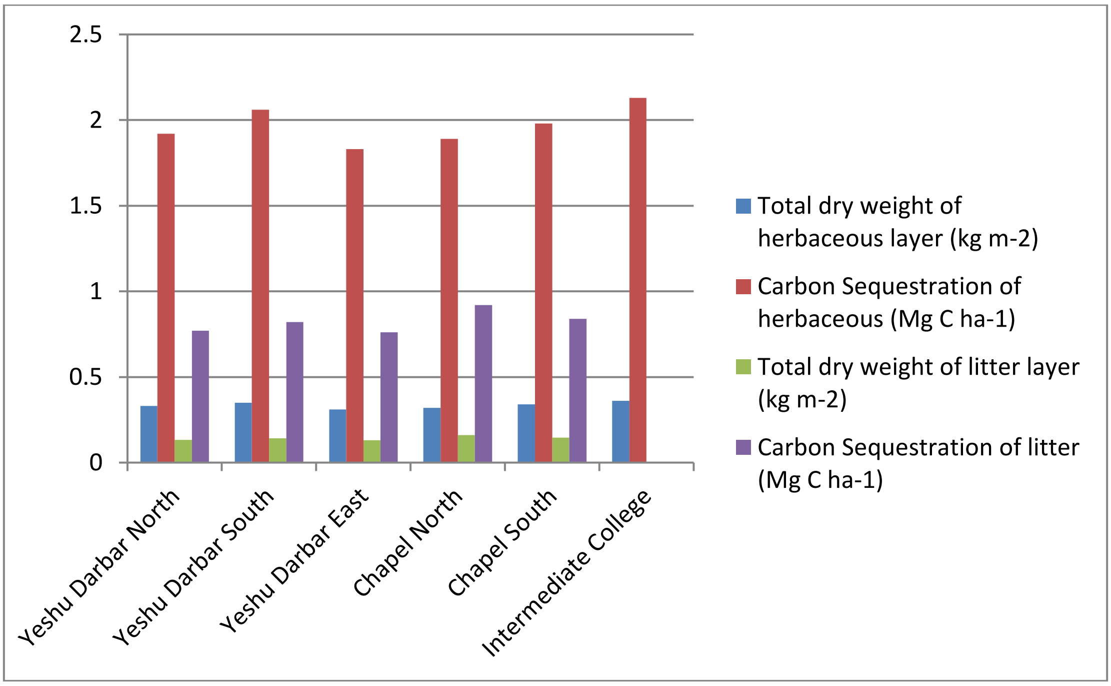

Fig. 1. Total dry weight and Carbon Sequestration of Herbaceous vegetation and Litter Layer of Home Garden Agroforestry System during Rainy Season in SHUATS Campus, Prayagraj

Table 2. Total dry weight and carbon sequestration of herbaceous vegetation and litter layer of home garden agroforestry system during winter season in SHUATS Campus, Prayagraj

Plots	Total dry weight of herbaceous layer (kg m^{-2})	Carbon Sequestration of herbaceous (Mg C ha^{-1})	Total dry weight of litter layer (kg m^{-2})	Carbon Sequestration of litter (Mg C ha^{-1})
Yeshu Darbar North	0.24	1.39	0.195	1.13
Yeshu Darbar South	0.26	1.53	0.191	1.1
Yeshu Darbar East	0.22	1.29	0.183	1.05
Chapel North	0.23	1.31	0.216	1.25
Chapel South	0.25	1.42	0.209	1.21
Intermediate College	0.28	1.65	0.205	1.19
F-test	**S**	**S**	**S**	**S**
CD@5%	0.031	0.018	0.019	0.012
SE(m)	0.010	0.006	0.006	0.004
SE(d)	0.015	0.009	0.009	0.005

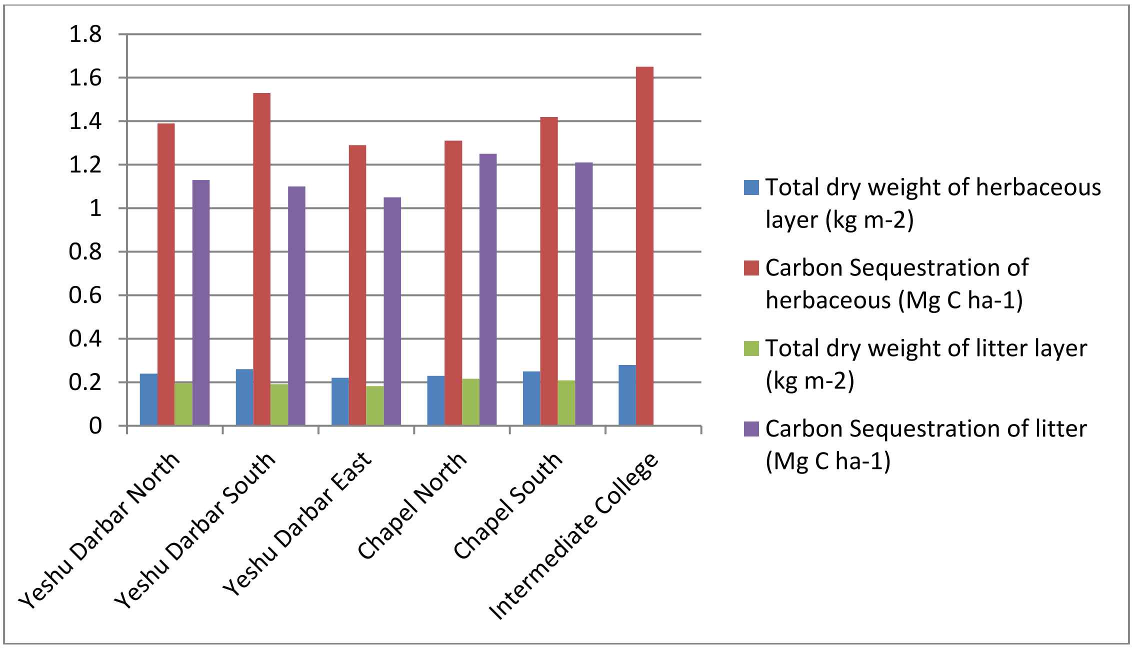

Fig. 2. Total dry weight and Carbon Sequestration of Herbaceous vegetation and Litter Layer of Home Garden Agroforestry System during Winter Season in SHUATS Campus, Prayagraj.

3. Carbon sequestration of herbaceous vegetation and litter layer of home gardens during summer season (Zaid - March to June)

Total dry weight and Carbon density of herbaceous Layer and litter layer in home gardens during Summer Season of SHUATS Campus, Prayagraj.

Table 3 depicts the data relevant to the calculation of carbon sequestration of herbaceous vegetation and litter layer in homegardens across selected areas of the SHUATS Campus, Prayagraj in Summer (Zaid) - March to June Highest total dry weight value of herbaceous vegetation was observed in Intermediate College (0.361kg m^{-2}) followed by Yeshu Darbar South (0.35kg m^{-2}) Chapel South (0.333kg m^{-2}) Yeshu Darbar North (0.311kg m^{-2}) Chapel North (0.309kg m^{-2}) Yeshu Darbar east (0.303kg m^{-2}). In litter layer highest total dry weight value was observed in Chapel North (0.228 kg m^{-2}) followed by Chapel South (0.214kg m^{-2}), Intermediate College (0.210kg m^{-2}), Yeshu Darbar North (0.200kg m^{-2}), Yeshu Darbar South (0.190kg m^{-2}) Yeshu Darbar east (0.173kg m^{-2}). Results revealed that highest carbon density of herbaceous vegetation were observed in Intermediate College (2.10 Mg C ha^{-1}) followed by Yeshu Darbar South (2.03 Mg C ha^{-1}) Chapel South (1.93 Mg C ha^{-1}) Yeshu Darbar North (1.81 Mg C ha^{-1}) Chapel North (1.79 Mg C ha^{-1}) and Yeshu Darbar east (1.76 Mg C ha^{-1}). For Litter layer the highest carbon density was observed in Chapel North (1.32Mg C ha^{-1}) followed by Chapel South (1.24Mg C ha^{-1}), Intermediate College (1.22Mg C ha^{-1}), Yeshu Darbar North (1.16Mg C ha^{-1}), Yeshu Darbar South (1.10Mg C ha^{-1}), Yeshu Darbar east (1.00Mg C ha^{-1}). These findings are similar to [25,26,27].

Table 3. Total dry weight and Carbon Sequestration of Herbaceous vegetation and Litter Layer of Home Garden Agroforestry System during Summer Season in SHUATS Campus, Prayagraj

Plots	Total dry weight of herbaceous layer (kg m^{-2})	Carbon Sequestration of herbaceous (Mg C ha^{-1})	Total dry weight of litter layer (kg m^{-2})	Carbon Sequestration of litter (Mg C ha^{-1})
Yeshu Darbar North	0.311	1.81	0.19	1.16
Yeshu Darbar South	0.35	2.03	0.18	1.10
Yeshu Darbar East	0.303	1.76	0.16	1.0
Chapel North	0.309	1.79	0.24	1.32
Chapel South	0.333	1.93	0.22	1.24
Intermediate College	0.361	2.1	0.2	1.22
F-test	**S**	**S**	**S**	**S**
CD@5%	0.013	0.01	0.008	0.005
SE(m)	0.004	0.003	0.003	0.001
SE(d)	0.006	0.005	0.004	0.002

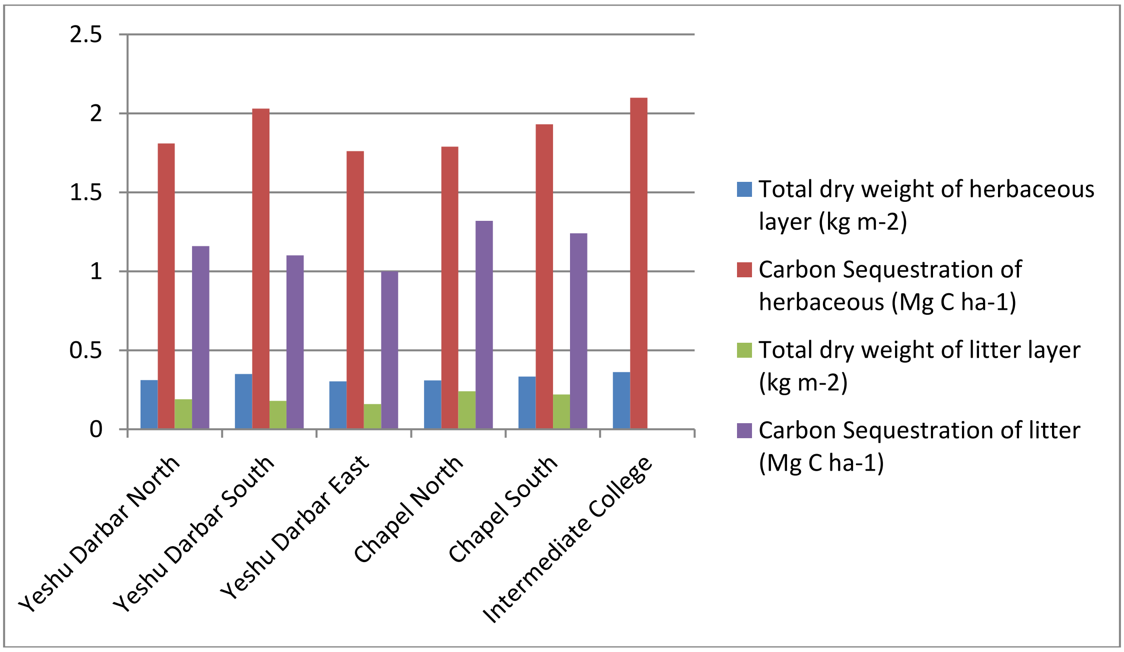

Fig. 3. Total dry weight and Carbon Sequestration of Herbaceous and Litter Layer of Home Garden Agroforestry System during Summer Season in SHUATS Campus, Prayagraj

4. CONCLUSION

Home gardens can play a crucial role in climate change mitigation by sequestering substantial amounts of carbon in their herbaceous vegetation and litter layer. The home garden agroforestry systems in SHUATS Campus, Prayagraj have significant potential for carbon sequestration. From the data, it is concluded that the total dry weight and carbon density of the herbaceous and litter layers in the home gardens of SHUATS Campus vary across different locations and seasons. The data concludes that the total dry weight of the herbaceous layer and litter layer in home gardens during the rainy season at SHUATS Campus, Prayagraj varied across different locations. The highest dry weight and carbon density of the herbaceous layer was observed in Intermediate College, followed by Yeshu Darbar South, Chapel South, Yeshu Darbar North, Chapel North, and Yeshu Darbar East. Similarly, the highest dry weight and carbon density of the litter layer was observed in Chapel North, followed by Intermediate College, Chapel South, Yeshu Darbar South, Yeshu Darbar North, and Yeshu Darbar East. During the winter season, the trends were similar, with Intermediate College having the highest dry weight and carbon density for both the herbaceous and litter layers. In the summer season, the same pattern was observed, with Intermediate College consistently having the highest values. The results found that Compare to all the areas Intermediate College area consistently had the highest dry weight and carbon density for both the herbaceous and litter layers, this indicates the area is potentially more productive and carbon-rich environment compared to the other areas. These variations are because of factors such as vegetation type, climate, and management practices. Thus, the variations among different plots and seasons, highlights the importance of considering seasonal variations in carbon sequestration assessments. The results highlight the importance of these systems in mitigating climate change by sequestering carbon. Thus, the herbaceous layer and litter layer of these systems play a crucial role in capturing and storing carbon.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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