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Simulating SOC Dynamics under Different Temperature Regimes and FYM Addition in Bamboo Species Using RothC-Model

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Abstract: To assess the impact of bamboo plantations on soil organic carbon (SOC) under prevailing climatic conditions, increase in temperature and soil amendments, the Roth C model was used. RothC is a promising model for the estimation of SOC changes in different land use systems. In the present study, the RothC model was used to predict the dynamics of SOC in the plantation of seven bamboo species under a usual scenario: increase temperature by 1 °C and 2 °C and farm yard manure (FYM) addition. The result revealed that RothC fairly predicts the SOC. The root mean square error (RMSE) value varied from 0.74 to 3.2 among seven bamboo species while comparing modeled and measured data. The increase in temperature resulted in a decrease in SOC. The decrease in SOC varied from 0.46 to 5.96 per cent as compared to the usual scenario, and the extent of the decrease varied from species to species. Among all species, the application of 9 t ha^{-1} FYM was found appropriate for maintaining the initial SOC level during the initial stage of bamboo growth.

Keywords: bamboo; RothC; RMSE; EF; soil organic carbon

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1. Introduction

Soil organic carbon (SOC) has a major influence on soil structure, water holding capacity, CEC, and the soil's ability to form complexes with metal ions and store nutrients and hence is vital for ecosystem functioning [1]. Variation in SOC content has a profound impact on soil functions. Soils are important carbon sinks to combat the challenges of climate and increasing atmospheric carbon dioxide concentration. The top 1 m soil profile has been estimated to store three times the amount stored in vegetation and double the amount in the atmosphere. However, this SOC is variable and is influenced by a number of factors. Land use systems, type of management practice, and age of the plantation affect SOC content in soil [2]. In the era of global warming and climate change, increasing concern about soil quality vis à vis soil organic carbon content and enhanced CO_2 concentration is being felt [3–5]. Therefore, management practices which can add SOC and still provide economic benefits to farmers are of urgent need to offset carbon emissions and fulfill Kyoto commitments and more recent commitments, e.g., the United Nations Framework Convention on Climate Change (UNFCC) 27th Conference of the Parties in Egypt (2022).

Recently, there has been increased interest amongst researchers and policymakers in the role of bamboo in enhancing soil carbon and carbon sequestration. Bamboo is a fast growing-plant and has the potential to solve climate-related problems of resource-poor farmers. India is the second richest country in the world, after China, in terms of bamboo genetic resources [6]. The bamboo area of the country is estimated to be 15.69 million hectares, with a total standing stock of 189 million tons [7]. Bamboo plantations are considered cost-effective solutions for the mitigation of CO_2 emissions and have the potential to modify climate change. Bamboo, due to fast growth, has a large capacity for biomass accumulation and a high potential for carbon storage from the atmosphere [8]. High litterfall and fine roots in bamboo also help in sequestering a large amount of carbon in soils [9]. Bamboo forest ecosystems store significant amounts of carbon ranging from 94 to 392 t C ha^{-1} [10]. Nathetal [9] and Yuen et al. [10] reported biomass and carbon sequestration rates as high as 13–24 Mg C ha^{-1} yr^{-1} for various types of bamboo worldwide. INBAR's modeling study revealed that a managed moso bamboo forest could accumulate about 300 t of C ha−1 after 60 years. Another report [11] revealed that monopodial (*P. pubescens*) sequestered more carbon than the Chinese fir in the first 5 years due to rapid early growth in southeast China.

Bamboo plantations sequester carbon in the soil at rates which are comparable to tropical agroforestry systems 9. In northeast India, a sequestration rate of 0.59 Mg ha^{-1} yr^{-1} for bamboo-based agroforestry systems has been reported [12]. Yuen et al. [10] reported that soil organic carbon (SOC) and total ecosystem carbon (TEC) ranged from 70–200 Mg C ha^{-1} and 94–392 Mg C ha^{-1}, respectively. Bamboo also produce phytolith occluded carbon, a stable form of carbon resulting from decomposing vegetation that remains in the soil for several thousand years. Parr et al. [13] estimated that the bio-sequestration of phytolith-occluded carbon by bamboo worldwide is equivalent to 11% of the current increase in atmospheric carbon dioxide. Huang et al. [14] reported that phytolith occluded carbon (PhytOC) produced by bamboo remains in the soil for thousands of years. The study of soil organic carbon dynamics in bamboo, therefore, is of immense importance.

Various soil models (Q, ROMUL, RothC, $SoilCO_2$/RothC, and Yasso07) and plant–soil models (CENTURY, Coup-Model and Forest-DNDC) have been used for studying soil carbon stock dynamics. Management, fertilization, crop rotation [15,16], and climate change [17] have been incorporated into different simulation models for predicting long-term changes in SOC [18–21]. The availability of input data, their simplicity, and whether modelled and measured values are good or unsatisfactory dictates the use of these models [22].

RothC is a model for the turnover of organic carbon in non-waterlogged topsoil that allows for the effects of soil type, temperature, soil moisture, and plant cover on the turnover process. The RothC model has been demonstrated by many authors to have performed very well for SOC [21]. It has been used under different climates, including tropical and temperate (humid subtropical, Mediterranean, and maritime) in over 80 countries [15,18,23,24]. In India, the Roth C model was used by Panwar et al. [25] for SOC variation in *Populus deltoides* W.Bartram ex Marshall plantations and Pal et al. [26] to see the effect of tillage on SOC. Bhattacharyya et al. [27] used RothC for a long-term fertilizer experiment in different climatic conditions in India; Afzali et al. [28] used Roth C for rangelands of Iran and reported that it accurately simulated the changes in SOC. The present study was conducted using the RothC model with the objectives of ascertaining the SOC potential of bamboo plantations, how SOC varies under bamboo plantations under increased temperature regimes, and what quantity of farm yard manure (FYM) needs to be incorporated to maintain the SOC of soil in the initial stages of bamboo growth.

2. Materials and Methods

2.1. Study Area and Experimental Details

The study was carried out at the Research farm of ICAR-Indian Institute of Soil and Water Conservation, Dehradun, India, located at 30°20′59″ N latitude and 77°53′05″ E longitude at 548 m above msl from 2012 to 2022 (Figure 1). The region has agroecological conditions typical of the Doon valley and lower Himalayan ranges. The soil contains 37% silt, 40% sand, and 23% clay and belongs to the silty clay loam type. The pH ranges within 5.4–5.6 with medium organic carbon (0.63%–0.73%), high bulk density (1.43–1.5 Mg m^{-3}), and low hydraulic conductivity (0.9–1.8 cm h^{-1}).

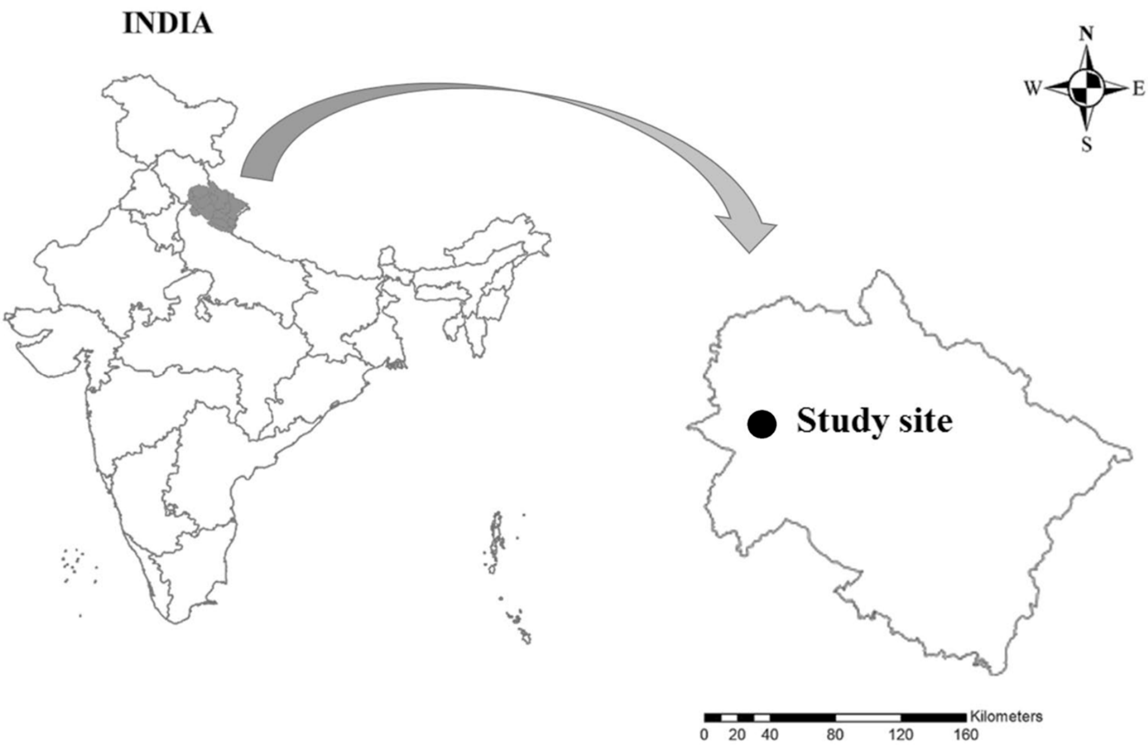

Figure 1. Location of the study site.

Seven commercial bamboo species viz., *Bambusa balcooa* Roxb., *Bambusa bambos* (L.) Voss, *Bambusa vulgaris* Schrad ex Wendl., *Bambusa nutans* Wallich ex Munro, *Dendrocalamus hamiltonii* Nees & Arn. Ex Munro, *Dendrocalamus stocksii* (Munro.) Naithani and *Dendrocalamus strictus* (Roxb.) Neest. were planted at 5 m × 4 m in a randomized complete block design (RCBD) with three replications in the year 2012. In total, there were 21 plots of 180 m^2, with 9 bamboo clumps in each block covering an area of 3780 m^2. The experiment was conducted under rainfed conditions. The plantation raised for the experiment was cleaned regularly by adopting standard management practices recommended for bamboo, except for the use of manures and fertilizers. Soil samples were collected initially in each of the 21 plots from the 0–30 cm soil depth in the year 2012. Soil samples were again collected in the year 2018 (after 6 year of planting) and in the year 2022 (after 10 years of planting). All the collected samples were analyzed for soil organic carbon according to the method of Walkley and Black [29].

2.2. Description of the RothC Model

RothC-26.3 is a model for the turnover of organic carbon in non-waterlogged topsoils that allows for the effects of soil type, temperature, moisture content, and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (t ha^{-1}), microbial biomass carbon (t ha^{-1}), and Δ14C (from which the equivalent radiocarbon age of the soil can be calculated) on a year to centuries timescale. The RothC model considers the effect of soil type, temperature, moisture content, and plant cover on the SOC conversion processes [30]. SOC stock comprises five compartments as a function of the speed of decomposition, four of these are considered active, (1) easily decomposed plant material (DPM, remains in the soil for 0.17 years), (2) microbial biomass (BIO, 1.69 years), (3) resistant plant material (RPM, 2.31 years), (4) humified organic matter (HUM, 49.5 years), and one passive, (5) inert organic matter (IOM), with a mean residence time of years. The DPM and RPM compartments decompose and become BIO and HUM and contribute CO2 to the atmosphere. The model includes a function that adjusts the proportions of BIO, HUM, and CO2 according to the soil clay content.

The input parameters for the model include mean temperature, monthly mean precipitation, mean monthly evaporation, clay content, soil depth, monthly C input from plant residues, organic fertilizers, and the number of months soil is covered. The details of the input parameters used in the present study are provided in Table 1. The model also requires plant residues that enter the soil at monthly intervals. The partition between the plant residues (PR) that enter the soil is given as a function of the default values originating from the DPM/RPM ratio. DPM/RPM is an estimate of the decomposability of the incoming plant material. Agriculture and cultivated grasses have a DPM/RPM ratio of 1.44; bushes and grasses, 0.67; tropical or deciduous forests, 0.25. The input of clay content in the model is used to calculate how much plant-available water the topsoil can hold; it also affects the way organic matter decomposes. It is necessary to indicate whether or not the soil is vegetated because decomposition has been found to be faster in fallow soil than in cropped soil, even when the cropped soil is not allowed to dry out. To access the impact of climate change on SOC, two increased temperature scenarios of 1 °C and 2 °C were created. The average monthly existing temperatures were arithmetically increased uniformly for all months in such a way that the average yearly temperature increased just by 1 °C and similarly for 2 °C. These two temperatures were taken as these are the likely increases in temperature up to 2050.

Table 1. Data requirement for RothC.

Average monthly temperature [a]	J (12.4), F (15.5), M (19.1), A (24.5), M (28.1), J (28.9), J (27.9), A (27.6), S (26.9), O (22.6), N (19.2), D (13.6); Average yearly temp. 22.2 °C
Average monthly temperature (1 °C increase) [b]	J (13.0), F (16.3), M (20.1), A (25.7), M (29.5), J (30.3), J (29.3), A (29.0), S (28.3), O (23.7), N (20.1), D (14.3); Average yearly temp. 23.3 °C
Average monthly temperature (2 °C increase) [b]	J (13.5), F (16.9), M (20.8), A (26.7), M (30.6), J (31.5), J (30.4), A (30.1), S (29.3), O (24.6), N (20.9), D (17.8); Average yearly temp. 24.2 °C
Precipitation (mm) [a]	J (23.8), F (17.3), M (21.6), A (38.6), M (27.3), J (161.2), J (536.9), A (463.6), S (255.6), O (4.8), N (7.9), D (7.5)
Open pan evaporation (mm) [a]	J (43.8), F (46.8), M (105.0), A (147.2), M (197.1), J (130.2), J (73.4), A (68.2), S (74.5), O (71.1), N (51.4), D (34.4)
Soil depth (cm)	30
Clay content (%)	23%
DPM/RPM [c]	0.67

[a] The weather data were taken from a nearby meteorological station of ICAR-IISWC, Dehradun; [b] values taken for RothC for modeling temperature scenarios; [c] The value suggested by Coleman and Jenkinson (1999) [30] was used.

2.3. RothC Model Simulations

RothC 26.3 model simulation was carried out in two stages: initialization and prediction. The initialization stage assumes that the SOC content measured in the systems achieves a condition of equilibrium [31,32]. RothC-26.3 is designed to run in two modes: 'forward', in which known inputs are used to calculate changes in soil organic matter, and 'inverse', when inputs are calculated from known changes in soil organic matter. In the present study, the RothC model was run in inverse mode to obtain the quantity of C that enters the soil yearly to maintain the specific initial SOC content (SOC) measured in the study. The equilibrium condition at the start of the experiment is achieved by running the RothC iteratively for 10,000 years. An equilibrium run requires an IOM value. This IOM value was calculated from Equation (1), provided by Falloon et al. [22].

$$\text{IOM (t ha}^{-1}\text{)} = 0.049 \times \text{SOC } 1.139, \quad (1)$$

where SOC = initial soil organic carbon (t ha^{-1}).

The equilibrium run determines the initial distribution of C in four compartments viz. decomposable plant material (DPM), resistant plant material (RPM), microbial biomass carbon (BIO), and humified organic matter (HUM) are necessary for the model to function along with its radio carbon. The DPM/RPM ratio used was 0.67, as recommended by RothC (by default) for bushes and grasses. The inputs required for running equilibrium are provided in Table 1. The weather (monthly temperature, rainfall, and evaporation; clay % and soil depth) and land management (plant residue, FYM, and soil cover) DPM/RPM ratios were used in direct mode.

2.4. Evaluation of RothC Model Performance

The model's performance was ascertained by comparing pairs of SOC data observed and predicted during the plantation years [21]. The statistics used were root mean square error (*RMSE*), Equation (2), and the efficiency of the model (EF), Equation (3). *RMSE* ranges from 0 to ∞ and *EF* from −∞ to 1.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(O_i - P_i)^2}{n}} \quad (2)$$

$$EF = 1 - \frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}\left(O - \overline{O}\right)^2} \quad (3)$$

where O = observed value, P = predicted value, and n = number.

3. Results

3.1. Measured and Modeled SOC under Prevailing Climatic Conditions

Modeled SOC in all the bamboo species decreased in the initial four years, and after the fifth year onwards, the SOC started increasing (Figure 2). The observed SOC values also reflected the same trend. The SOC under *B. nutans* was initially 17.80 Mg ha^{-1}, which reduced to 15.56 Mg ha^{-1} after 5 years of plantation and then increased to the initial level of 17.76 Mg ha^{-1} after 10 years of plantation (Figure 2). In a similar way, other species also had similar trends for observed SOC values. The CO_2 evolution from the bamboo plantation during the simulated period followed the trend of the SOC variation (Figure 3). Statistics were employed to describe the relationship between measured and modeled values (Table 2). The agreement between the modeled and measured data is satisfactory, as the RMSE value for bamboo species varied from 0.74 to 3.2. This signifies that modeled SOC data was much closer to measured data. Model efficiency (EF) varied from −20.32 to 0.94. The EF for *B. vulgaris* was much less, indicating RothC is not suitable for the species. Hence, for further scenarios, the species was not taken. The data for other species signify near prediction of SOC using RothC (Table 2).

Table 2. Statistics describing performance of model for each treatment.

Treatments	RMSE *	EF $
Bambusa nutans	1.63	0.18
Bambusa balcooa	2.43	−0.04
Bambusa bambos	0.74	0.88
Bambusa vulgaris	3.20	−20.32
Dendrocalamus hamiltonii	2.81	−0.21
Dendrocalamus stocksii	0.91	0.94
Dendrocalamus strictus	1.34	0.89

*—root mean square error; $—Model efficiency.

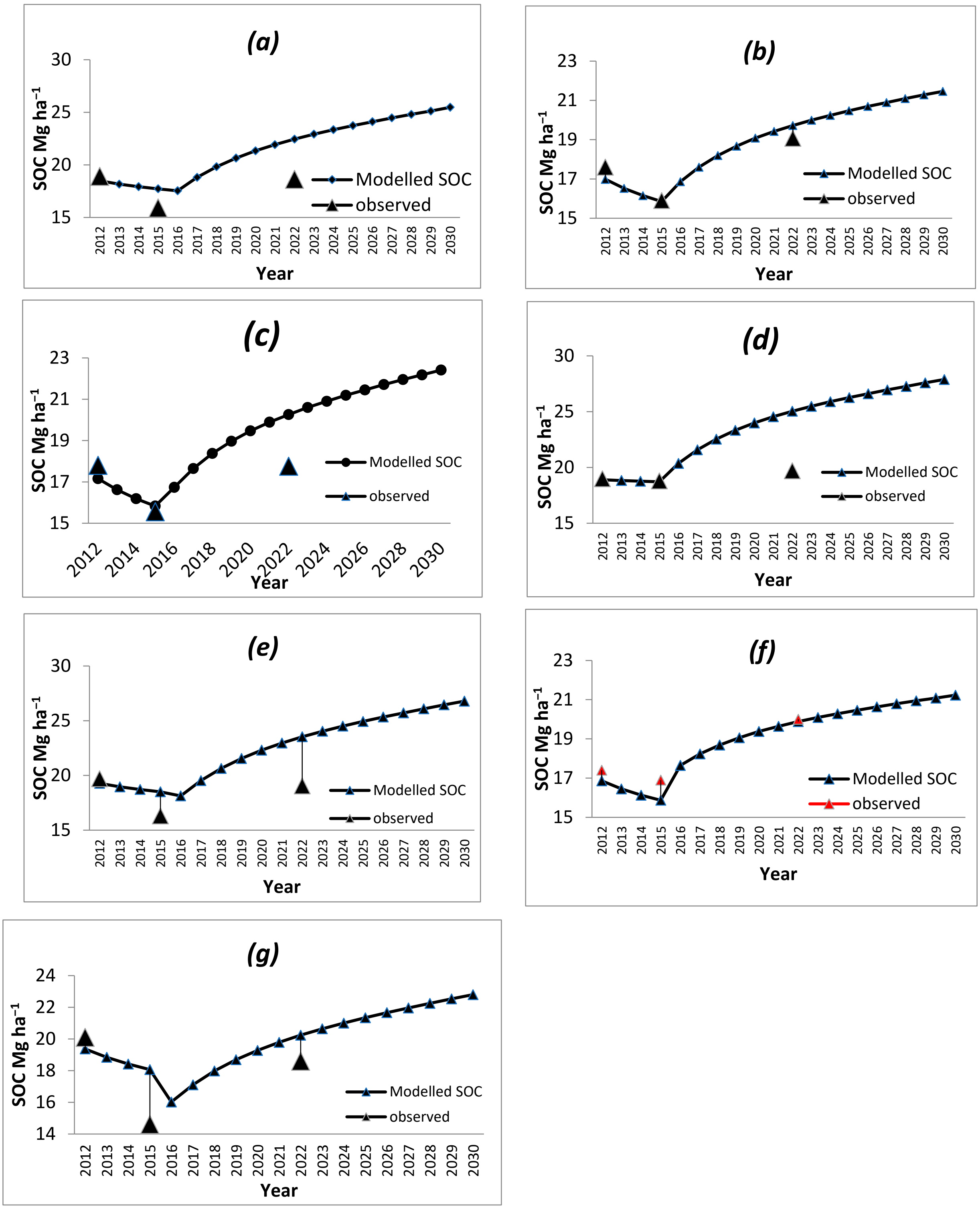

Figure 2. Observed and modeled SOC under a usual scenario in (**a**) *B. balcooa*, (**b**) *B. bambos*, (**c**) *B. nutans*, (**d**) *B. vulgaris*, (**e**) *D. hamiltonii*, (**f**) *D. stocksi* and (**g**) *D. strictus*.

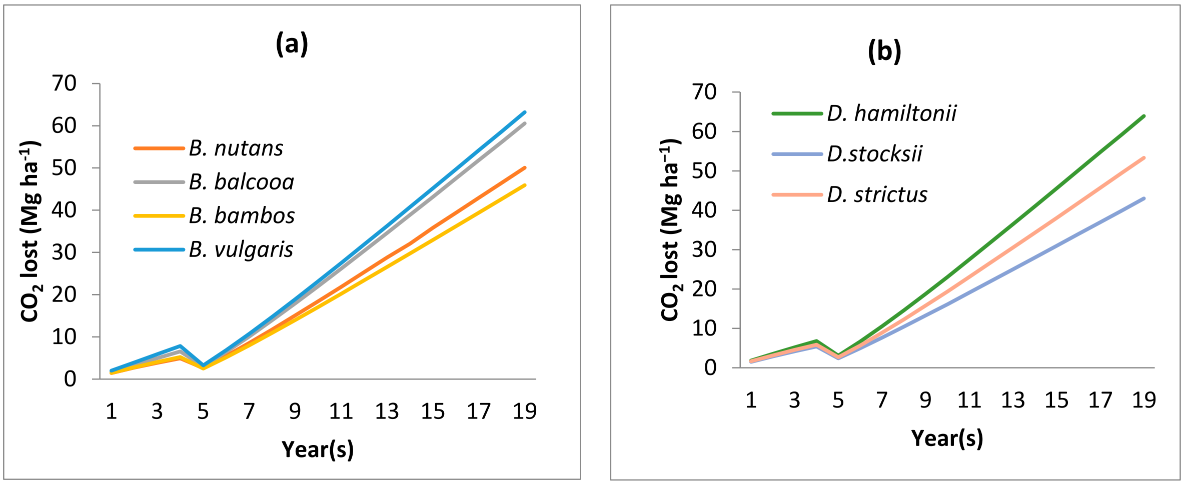

Figure 3. CO_2 evolution under a usual scenario in (**a**) *Bambusa* species and (**b**) *Dendrocalamus* species.

3.2. Effect of Climate Change on SOC

The impact on SOC level under bamboo species with a likely climate change of 1 °C and 2 °C increase in temperature was modeled considering that RothC model fairly predicted the results under prevailing climatic conditions. It was observed that the SOC decreased with an increase in temperature (Figure 4). The range of decrease in SOC varied from 0.46 (*D. hamiltonii*) in the first year to 3.04 per cent (*B. balcooa*) after 15 years of simulation, when 1 °C increase in temperature was modeled. With the increase in temperature to 2 °C, the range of SOC decrease was 0.95 (*B. bambos* and *D. stocksii*) in the first year to 5.97 per cent (*B. nutans*) after 15 years of simulation.

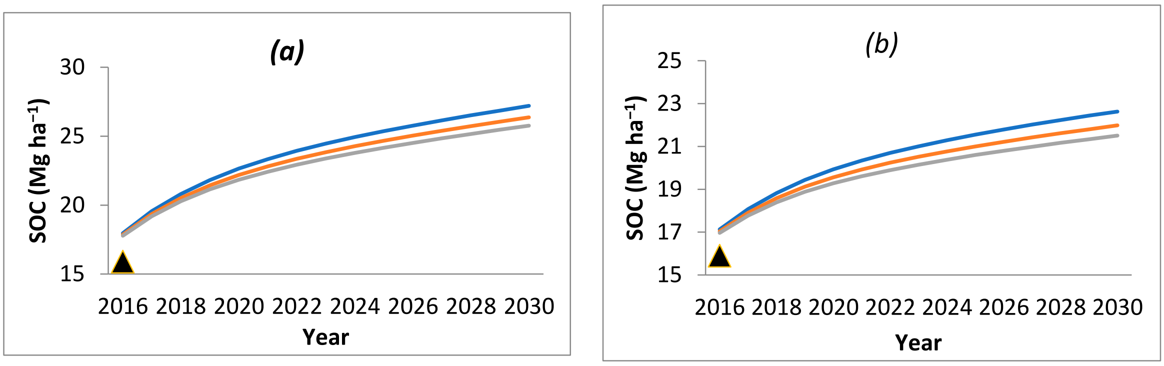

Figure 4. *Cont.*

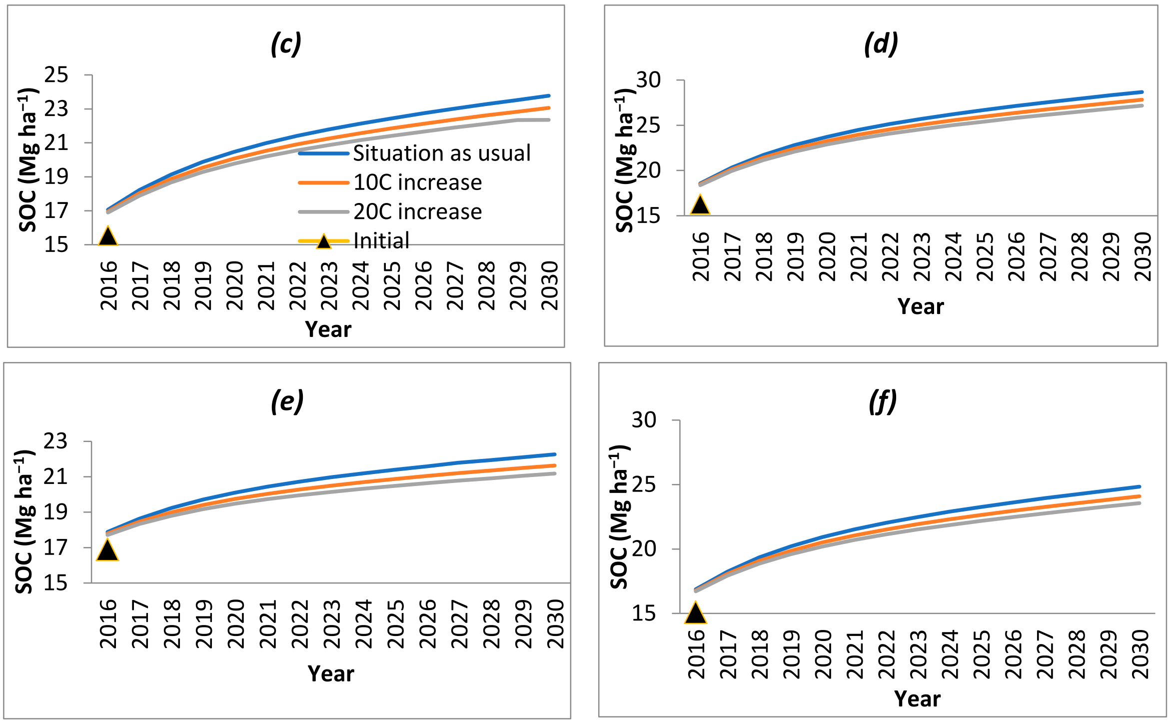

Figure 4. SOC variation as a result of increase in temperature in (**a**) *B. balcooa*, (**b**) *B. bambos*, (**c**) *B. nutans*, (**d**) *D. hamiltonii*, (**e**) *D. stocksii* and (**f**) *D. strictus*.

3.3. Maintaining SOC: Addition of Organic Inputs

The observed data for all the bamboo species and consequently modeled data for the corresponding period revealed that in the initial stages of bamboo plantation, SOC reduces. Through the RothC model, it was ascertained at what rate organic manures (farm yard manures; FYM) should be applied to the bamboo so that the SOC levels do not reduce and are retained to the near-original SOC values. Different rates of FYM application (@ 5 t ha^{-1}, 7 t ha^{-1}, 8 t ha^{-1}, and 9 t ha^{-1}) were modeled, and it was observed that FYM applied @ 9 t ha^{-1} helps in maintaining the initial SOC level (Figure 5). However, this will also result in an increase in CO_2 (Figure 6).

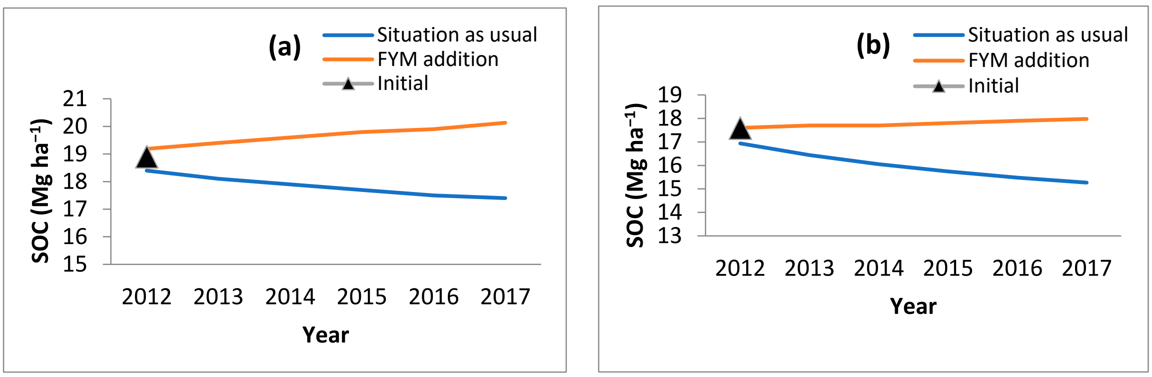

Figure 5. *Cont.*

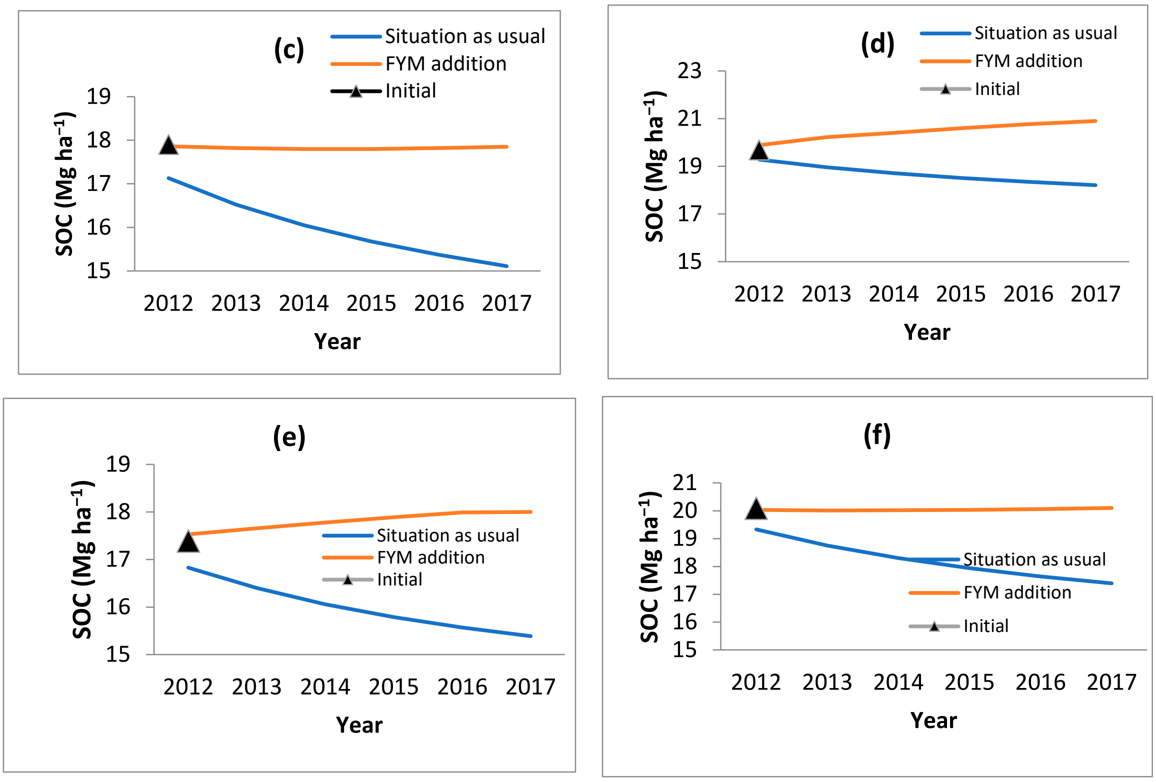

Figure 5. Change in SOC with addition of FYM @ 9 t ha^{-1} in (**a**) *B. balcooa*, (**b**) *B. bambos*, (**c**) *B. nutans*, (**d**) *D. hamiltonii*, (**e**) *D. stocksii* and (**f**) *D. strictus*.

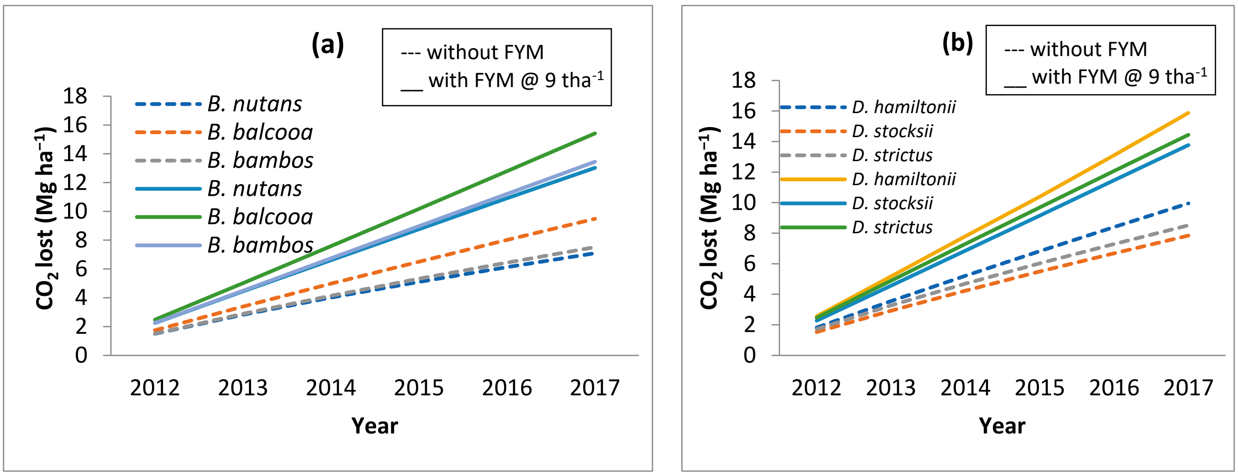

Figure 6. CO_2 evolved as a result of addition of FYM @ 9 t ha^{-1} in (**a**) *Bambusa* species and (**b**) *Dendrocalamus* species.

3.4. Effect of Increase in Temperature and FYM Addition on SOC

Keeping 9 t ha^{-1} FYM additions to maintain SOC level in the initial stage of bamboo growth (as modeled above) and increase in temperature by 1 °C and 2 °C (the likely climate scenario), the SOC was modeled through RothC (Figure 7). It was observed that with an increase in temperature, the SOC decreased. The decrease in SOC with 1 °C increase in temperature varied from 1.17 in *D. stocksii* to 1.79 per cent in *B. nutans* after the 6th year of plantation. When 2 °C simulated an increase in temperature, the decrease in SOC varied from 2.44 in *D. stocksii* to 3.03 per cent in *B. balcooa* after the 6th year of plantation. The CO_2 also increased correspondingly with an increase in temperature.

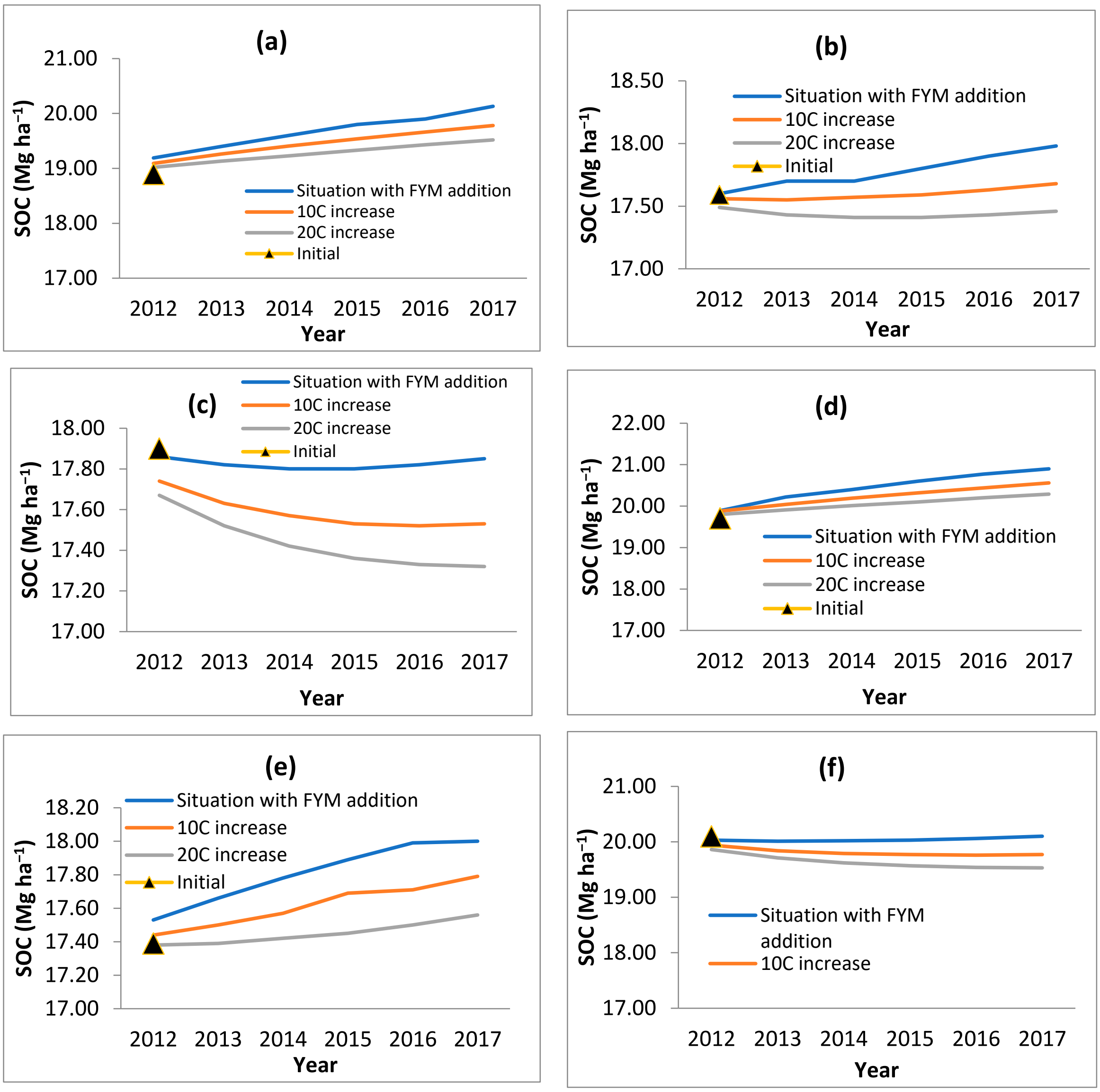

Figure 7. Effect of temperature increase on SOC with FYM addition @ 9 t ha^{-1} (**a**) *B. balcooa*, (**b**) *B. bambos*, (**c**) *B. nutans*, (**d**) *D. hamiltonii*, (**e**) *D. stocksii* and (**f**) *D. strictus*.

4. Discussion

4.1. Measured and Modeled SOC under Prevailing Climatic Conditions

The dynamics of soil carbon are critical and contribute significantly to carbon cycling and the sustainability of terrestrial ecosystems [33]. Though the C sequestration potential of bamboo is well established [34,35], there are few studies that reflect the changes in the SOC pools under bamboo plantations, which are significant from a C storage point of view since a minute change in the SOC pools could change the atmospheric CO_2 concentration [36].

It was observed that the SOC initially decreased and then increased after the 5th year of plantation (Figure 2). The buildup of soil organic matter and nutrient turnover is affected by the input of nutrients through the leaf, stem, branch, and root [37]. The initial dip in SOC under bamboo may be ascribed to less amount of leaf litter addition during the establishment phase (1–4th year), due to which they could not exert a remarkable effect on SOC [38]. Additionally, during the establishment phase, the interspaces were ploughed mechanically to check the weed growth, which might have resulted in the loss of accumulated carbon to the atmosphere. Sainju et al. [39] reported that deep tillage applied in the intensive management regime would break up the soil profile and improve the aeration condition, and subsequently increase the exposure chance of SOC to decomposers. Wang et al. [40] also reported that the removal of forest understory vegetation decreased the C input into the soil, which may have contributed to the decrease in SOC storage. Removal of weeds and understory growth also may have resulted in an increase in soil temperature, thereby enhancing mineralization. Additionally, the fast growth rate of bamboo (the ability to complete the growth cycle within a short temporal scale of 120 to 150 days) makes it a highly potent species for SOC and nutrient exploitation initially [41].

However, overlooking initial disturbance, bamboo enhanced the active pool of SOC, and land use changes induced C losses and thus could easily restore the degraded lands under bamboo cultivation [42]. The projected increase in soil organic carbon content under various bamboo species may be attributed to the addition of varying amounts of leaf litter (Figure 2) and different decomposition rates. In general, perennials have the ability to maintain soil organic matter through the supply of litter and root residues. Fine root turnover is another important flux of soil organic C with an amount of C equal to leaf litter [43]. Bamboo species, due to fast growth, may allocate more biomass to their roots, which can transfer more root detritus to the soil and hence higher SOC accumulation in the long term. The fine roots and root hairs of the bamboo root system play a significant role in supporting high productivity and buildup of soil organic carbon [44]. Singh and Singh [45] reported that the introduction of bamboo resulted in a progressive buildup of soil organic carbon and increasing nutrients being immobilized in microbial biomass with increasing age of the plantation. Similar buildup in soil OC was also reported for *Bambusa pallida* [46], *Gigantochloa* spp., *Bambusa vulgaris*, and seven 12-year-old commercial bamboo species [38]. Christanty et al. [47] also reported that bamboo resulted in an increase in soil organic matter of approximately 7 tons ha^{-1} to 25 cm depth during the 4-year fallow period in the rotation cycle of shifting cultivation.

On the contrary, Friggens et al. [48] did not record any increase in net ecosystem C stock 12 or 39 years after planting in two native species (*Betula pubescens* and *Pinus sylvestris*). Contributing factors for SOC increase are temperature, soil condition, clay fraction, management practices, and the species itself, either alone or in combination with all these factors. Dwivedi et al. [49] reported that the stable fraction of C is strongly bound with the soil mineral matrix to form mineral–humus complexes and thus are shielded from microbial action and least decomposed. Bamboos are known to produce phytolith occluded carbon (PhytOC) from decomposing vegetation which is highly stable and remains in the soil for several thousand years [13,14]; hence, long-term bamboo plantation can add to carbon sequestration. If current trends continue, bamboo plantations may show significantly higher soil C storage.

4.2. Scenario for Climate Change and FYM Addition

By modeling the scenario of the impact of a likely increase in temperature, it was found that SOC decreases with an increase in temperature (Figure 4). Climate factors, such as precipitation and temperature, significantly affect SOC content which is the basic component of the global carbon cycle, particularly in the context of climate change [50–53]. Under climate change scenarios, most studies [54,55] have reported losses from the soil organic carbon. Increased temperatures might enhance the release of CO_2 to the atmosphere from SOC. Temperature increases will accelerate decomposition and, consequently, increase the loss of SOC stock in the upper layer of the soil [56]. As reported by Xu et al. [57] using the RothC model, results indicated that SOC stock would decrease by 2%–6% over 40 years under the climate change scenarios in the rangelands of southern Ireland. Using the CarboSOIL model, Muñoz Rojas et al. [55] also showed that climate change had a negative impact on SOC contents in the upper layers of the soil section in Andalusia. Jebari et al. [51], also using the RothC model, predicted that SOC content will decrease in the different climate change scenarios in comparison with no climate change scenario for future decades overall in Spain.

A series of studies have shown that the environmental factors controlling soil organic carbon differ depending on the scale [58,59]. With an increase in temperature, soil microbial decomposition activity is enhanced, which leads to a higher soil organic carbon output. The soil organic carbon content depends on the balance between the carbon input and output, and environmental factors affect soil organic carbon by impacting the input and/or output of carbon [60,61]. In terrestrial ecosystems, the carbon input is related to plant productivity, whereas the carbon output mainly depends on microbial organic matter decomposition [58,62].

RMSE values with the RothC model are reported in the range of 2%–30% [21,23,34–62]. EF was −20.32 to 0.94. González-Molina et al. [63] also reported an EF range from 0.32 (grasslands) to 0.90 (forests) and concluded that RothC performs better in agriculture and forest land compared to grasslands and rangelands. Barančíková et al. [64] reported that the RothC modeled and observed values are fairly close to each other, and RothC is a good model for the prediction of SOC. The model simulated an increase in CO_2 with an increase in temperature and application of FYM (Figure 6). The increasing temperature will expedite the decomposition of soil organic matter and tend to increase SOC loss in the future.

5. Conclusions

The results obtained conclude that the RothC 26.3 model is suitable for the estimation of SOC stock changes under different bamboo species. The RMSE value range (0.74 to 3.2), and the EF value range (−20.32 to 0.94), suggest that RothC modeled values are near to the observed values of SOC for the bamboo plantations. In India and other developing countries, bamboo are seldom raised in fertile soil, and degraded soils are allotted for bamboo plantations. The observed Soc values suggest a decrease in SOC; such trends warrant external inputs to maintain soil fertility. Simulation with FYM addition suggests that 9 t ha^{-1} FYM should be added at the time of plantation or within three years of plantation to avoid a decrease in initial SOC content due to vigorous bamboo growth. An increase in temperature (simulated at 1 °C and 2 °C) in the event of climate change would reduce SOC content ranging from 0.46 per cent to 5.97 per cent over 15 years of simulation (up to the year 2030) compared to initial SOC status. This suggests taking appropriate soil management measures to maintain SOC under changing climate scenarios.

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