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The Role of Fruit Trees in Absorbing and Sequestering Carbon: (Article Review)

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ABSTRACT
The rapid increase in atmospheric carbon dioxide (CO_2) concentration, and greenhouse gases presents one of the problems and challenges facing environment due to its effect on climate change. Thus, urgent action is needed to mitigate the risk of climate change by capturing carbon in the atmosphere., which can be done by plants and soil and in natural biological processes such as photosynthesis, are absorbed and. Efficiency of carbon sequestration by absorption through different plants with photosynthesis and fixing it as the carbon in plant and soil biomass, and its management between the systems is very large due to characteristics, Growth rate, production of biomass, and environmental elements. This article aims to explore the role of fruit trees and their capacity to store carbon, and how this can contribute to sustainable development, as well as how to calculate the amount of carbon seized. A review of studies and research reveals that fruit orchards are distinguished by their long life cycles and extensive plant and root systems, which provide high efficiency in sequestering carbon from the atmosphere. The carbon sequestration performance of fruit crops and their management systems may vary due to the nature of their growth and development, physiological processes, biomass characteristics, and environmental conditions. These solutions can become a key element in reducing greenhouse gas emissions and mitigating global warming, ultimately underscoring the importance of sustainable agriculture in carbon sequestration, reducing carbon dioxide levels, and mitigating global warming, thereby protecting and enhancing genetic diversity.

***Keywords*:** carbon sequestration; fruit trees; orchards; climate change mitigation; soil organic carbon.

INTRODUCTION

Climate change is an incredibly complex problem and one of the most serious challenges due to the magnitude of [D1.1]destruction it causes and complexity in managing it. It is a clearly a threat to ecosystems and biodiversity. Since In the 19th century human activities have been the major reason for climate change as burning of fossil fuels i.e, coal, oil and gas have converted lot of carbon into carbon dioxide emission creating greenhouse gases trapping solar heat causing warm up. As a consequence, higher amounts of carbon dioxide, methane, and other active gases are released to the atmosphere verses the amounts of CO2 removed in natural processes and their imbalance directly and indirectly touches all living things [1, 2].

The concept of greenhouse effect arises during the warming up of the Earth by solar radiation and its warm surface losing heat in space. Some of this heat is trapped by certain gases; these gases are known as greenhouse gases. The main greenhouse gases consist of water vapor, carbon dioxide and methane. Heat is absorbed by gases and some of it is reflected back to the Earth, warming the surface. This is often known as the greenhouse effect. [3].

The increasing concentration of one of the greenhouse gases (especially CO2) in the atmosphere, are a source that is taken seriously because it is linked to climatic changes. It is present in all organisms and is the building block of life in Earth, but this element has several appearances in nature. Carbon is a biological essential element which is found in plant biomass, soil, geological sediments and the atmosphere as well as being present in seawater as dissolved species.[4]. A report issued by the Intergovernmental Panel on Climate Change confirmed that rising average temperatures have affected different ecosystems and livelihoods around the world, [5;6]Hence the need for adjustment to climate change and for tools that can be implemented to moderate it through systems which control these emissions , as well as how to sequester and isolate carbon by handy farming practices which absorb CO 2 from the air, storing carbon mainly in plant biomass (including root, stem, branch, and leaf) Therefore, there must be options and proposals for carbon management, and one of these options is planting fruit trees in carbon sequestration sites and assessing their potential [7, 8, 9].Horticultural crops in general and fruit bearing trees in particular have been reported to be sources of nutritional supplements plants [6]. fruit trees contribute significantly to mitigating the effects of climate change and reducing carbon dioxide emissions from the atmosphere, due to their ability to store and retain carbon in their tissues [10, 11]. Because of their different composition from other crops and their wide distribution in agricultural systems, fruit trees are grown in orchards, farms and agricultural lands. systems, they are found in orchards, farms, and agricultural lands.

A study by (12) identified the carbon sequestration potential of fruit trees. This study compared the carbon sequestration potential of citrus and mango trees and examined the relationship between management practices and carbon sequestration in fruit trees. The results showed higher biomass and carbon sequestration in mango trees compared to citrus trees (74.57 ± 14.95 and 13.52 ± 1.25 tons/hectare, respectively). Significant differences in carbon sequestration were also observed with varying management practices ($p < 0.05$). These results suggest that mango fruits have a high capacity to absorb carbon emissions, thus mitigating global warming.

. This implies the possibility that cultivation of fruit trees will prove to be a tool that appears beneficial for good agricultural practices, for sustainability and maintenance of environmental equilibrium via the ‘‘possibility of biological carbon sequestration,’’ after the shrinkage of forest areas & augmented agricultural lands [13,14, 15, 16, 17, 18, 19].

Therefore, the article aims to:

1. Assess the role of fruit trees in sequestration and uptake of atmospheric CO2 and their impact on climate change.
2. Work out how much carbon trees can store

The Role of Agriculture in Carbon Sequestration and Achieving Sustainability

Agriculture is a key element in combating the climate change crisis, as it contributes to carbon sequestration (curbing greenhouse gas emissions, especially carbon) through sustainable farming and forest conservation efforts, leading to a more sustainable future. Reports indicate that carbon sequestration in agriculture during the remainder of this century has the potential to offset 4% of the carbon increase resulting from human activities. This can be achieved through:

1- .Planting: Trees and plants absorb carbon from the air and store it in their roots and leaves.

2-Soil: Rich in microorganisms, soil stores carbon and increases its fertility. Soil texture and mineral composition affect the mechanism of carbon fixation. For example, fine-textured soils, especially clay loam, have a greater capacity for storing carbon due to their large surface area and ability to clump together, thus protecting organic matter from microbial decomposition[20].

3-.Recycling agricultural waste—converting it into organic fertilizers—has a positive impact on reducing carbon emissions and improving soil quality [20]. It also improves soil quality and enhances plant disease control, without causing negative environmental impacts. Organic fertilizers have been obtained from organic waste, fruit scraps, agricultural residues, domestic wastewater, and animal manure[21].

These solutions have the potential to become a crucial element in reducing greenhouse gas emissions and mitigating global warming. This is because agriculture plays a vital role in mitigating global warming, preserving biodiversity, and achieving food security. Sustainable agriculture sequesters carbon and reduces atmospheric carbon dioxide levels, which in turn enhances biodiversity protection, combats soil erosion, and increases crop productivity. Agriculture effectively contributes to reducing greenhouse gas emissions such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Furthermore, it has enormous potential as a carbon sink through biological processes that store atmospheric carbon in soil organic matter and plant biomass, thus mitigating the effects of climate change. Many agricultural practices, such as tillage, agroforestry, and organic amendments, have demonstrated their effectiveness in improving soil structure and reducing erosion, thereby enhancing plant growth and increasing crop yields. Despite this, carbon sequestration applications face several challenges, including the limited carbon storage capacity of soils and variations between soil type and climate[22]. Soil carbon sequestration is considered one of the most effective strategies for mitigating the effects of climate change [22]. One of its advantages is increased agricultural production [3]. This not only reduces the impact of climate change but also strengthens the carbon cycle, as soil acts as both a source and a reservoir for greenhouse gases. Traditional farming methods have contributed to increased carbon emissions through deforestation and soil degradation, while sustainable agriculture offers significant opportunities for carbon sequestration. Practices such as cover cropping, reduced tillage, the use of organic amendments, and agroforestry can increase soil organic carbon stocks, improve soil health, and mitigate the effects of climate change [4]. However, the success of these practices depends on several factors, such as soil type and environmental conditions. Therefore, each region should have its own strategy to maximize carbon sequestration using agricultural systems (5). One such agricultural practice is conservation agriculture, where reducing tillage can reduce climate impacts by increasing soil carbon stocks. Conservation agriculture (no-till farming) also helps increase organic carbon storage by reducing soil disturbance to plant residues and decomposing organic matter, as well as providing protection for organic carbon. This, in turn, reduces erosion and thus the accumulation of organic carbon, as well as reducing the impact on soil structure and microbial communities (8). Bosio et al. [23] also highlighted the role of mixed farming (agroforestry), including the planting of trees and shrubs, in stabilizing soil carbon stocks and reducing erosion. This has led to the capture of airborne particles and polluting gases. It is estimated that agroforestry provides 0.28 gigatons of CO2 equivalent annually through additional carbon storage, demonstrating its importance as a key solution for mitigating climate change and a contributor to sustainable development. Caro and Akrawi [24] noted differences in carbon storage among various tree species, with the eastern juniper being a notable exception. Just seven trees stored 20.51 tons of carbon, sequestering 0.32 tons. Therefore, the results of this study can contribute to estimating the potential for reducing CO2 emissions through urban forests. When best practices are applied to agricultural land—whether orchards or fields—using a specific methodology, it becomes a measure of global warming potential. Integrating mitigation options (climate-smart agriculture, water management, cropping systems, nutrient management, etc.) and analyzing the global economic feasibility of these measures are crucial for the effective development of mitigation methods/technologies to reduce greenhouse gas emissions [25;26].

Carbon Sequestration and Storage in Plants and Soil

In plants: Carbon sequestration in plants is the process of capturing carbon dioxide resulting from human activities and preventing its accumulation in the atmosphere. This occurs through natural methods, represented by the absorption of carbon dioxide (CO_2) by trees, plants, and crops from the atmosphere through photosynthesis, and the ability of the tree to capture a amount of carbon stored in the form of carbohydrates, while returning part of this amount to the atmosphere through respiration. It also occurs through industrial methods, using carbon-capture technologies and storing it underground (27, 28, 29).

Atmospheric CO_2 is captured and stored in plants, soil, oceans, and the atmosphere in the form of biomass through photosynthesis. It is stored as carbon in the biomass of tree trunks, branches, leaves, and roots,growth rates, biomass accumulation, and environmental factors [4]. , thereby reducing greenhouse gas emissions, This finding was observed by Dixon et al. [30] that forests and soil have a key impact on the CO2 in atmosphere, due to the fact, plants are an important part of carbon cycle. However, the importance of trees in reducing carbon dioxide does not lie solely in the photosynthetic process in their tissues and their role in confronting climate change, but also in reducing energy depletion by lowering carbon-dioxide emissions from fossil burned by plants [31]. The thickness of above-ground tree biomass must be proportional to the significance of carbon components [32]. Thus, trees can reduce other types of gases, such as carbon monoxide (CO), whose pollution is a major global concern [7]. Plants are estimated to store no less than 350 petagrams of carbon, and it is estimated that up to 90% of terrestrial carbon in the world exists in plants [33]. Although forests have the ability to store high levels of carbon dioxide, the estimates of carbon storage in forests are subject to increase or decrease due to several factors, such as converting forest land to other uses and mining, leading to changes in carbon fluxes to the atmosphere. Carbon-sequestration rates vary according to tree species, soil type, climate, topography, and management practices [34]. [35], in their study to estimate forest biomass in order to determine the amount of carbon emitted during deforestation, showed that carbon retained in tree parts such as the stem, branches, leaves, and other parts was 146.005, 73.9333, 31.3812, and 249.9924 Mg ha^{-1} respectively. In general, crops are characterized by structural properties that allow them to absorb more carbon sources due to their life cycle and high photosynthetic activity.

In Soil: Soil: Rich in microorganisms, soil stores carbon and increases its fertility. Soil texture and mineral composition affect the mechanism of carbon fixation. For example, fine-textured soils, especially clay loam, have a greater capacity for storing carbon due to their large surface area and ability to clump together, thus protecting organic matter from microbial decomposition [28].

3. -Recycling agricultural waste—converting it into organic fertilizers—has a positive impact on reducing carbon emissions and improving soil quality [19]. It also improves soil quality and enhances plant disease control, without causing negative environmental impacts. Organic fertilizers have been obtained from organic waste, fruit scraps, agricultural residues, domestic wastewater, and animal manure [20].

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Figure1: The various processes through which trees and soil can gain and lose carbon.

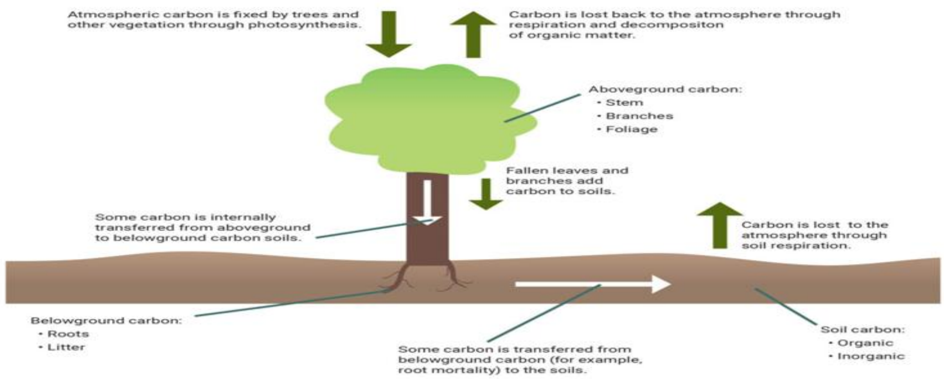

Figure1**:** The various processes through which trees and soil can gain and lose carbon.
Source: U.S Environmental Protection Agency [39].

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. Therefore, the results of this studies can contribute to estimating the potential for reducing CO_2 emissions through urban forests. When best practices are applied to agricultural land—whether orchards or fields—using a specific methodology, it becomes a measure of global warming potential. Integrating mitigation options (climate-smart agriculture, water management, cropping systems, nutrient management, etc.) and analyzing the global economic feasibility of these measures are crucial for the effective development of mitigation methods/technologies to reduce greenhouse gas emissions [43; 44]

The Role of Fruit Trees in Carbon Sequestration and Mitigating the Impact of Climate Change

Fruit-tree cultivation is a sustainable production system, as fruit orchards can contribute positively to sustainable development and to mitigating the effects of climate change, given the current expansion in agriculture and the rise in poverty levels. By absorbing carbon dioxide from the air, fruit trees help reduce its accumulation in the atmosphere through photosynthesis, just like other trees., just like any other tree This depends on the selection of various young trees and species and cultivars which are resistant to multiple environmental conditions in order to be able to encourage the process of farm lands carbon sequestration. Agricultural activities carried out in orchards, such as pruning, also contribute to providing wood biomass energy at times when demand for it increases due to the availability of a larger carbon sink. [43;44]. Nardino et al. [11] also mentioned the capacity of orchards in sequestering carbon and storing high quantities of carbon in their vegetative organs for a long time. This affirms that establishing and managing fruit trees offer a range of options for supporting the reduction of the impacts of climate change, being an option to carbon sequestration by forests and also lessening the dietary requirements within communities[45;46].

. Rajan[42].also noted that tall annual herbaceous crops like banana (Musa spp.), have a great potential to accumulate carbon (C) and create carbon dioxide (CO_2) sink in agricultural systems. They have a critical and substantial part in the carbon cycle, climate control and mitigating global warming. Thus, the assessment of carbon sequestration in fruit trees is very important for comparison purposes with traditional tree carbon stock and their its later integration into the C capture and sequestration systems. Tom-Dery et al. [46]. found higher carbon stock in mango trees than that of the citrus trees, suggested that this might be due to being taller and the larger diameter of mango trees than citrus Wu et al. [47]. also clarified that irregular pruning of fruit trees leads to a reduction in their biomass and therefore in their carbon stock.

Based on this, the trend has moved toward the cultivation of fruit trees to ensure food security and to combat climate change. The adoption of fruit-tree cultivation varies according to farmers' individual needs and land availability. Accordingly, farm sizes vary from small areas that contain only a few fruit trees surrounding the farm to large orchards [48; [49]. The following figure shows the contribution of fruit trees to a sustainable environment.

The following figure illustrates the contribution of fruit trees to a sustainable environment.

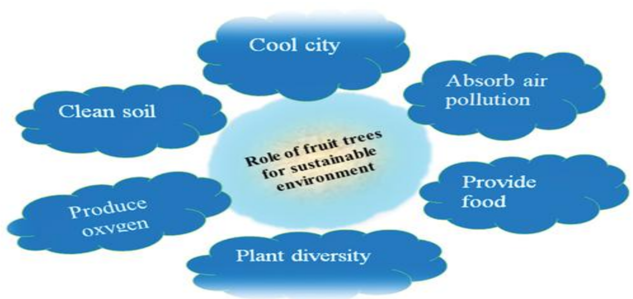

Figure 2 **:** Contribution of Fruit Trees to a Sustainable Environment

Source: Gelaye and Getahun, [50].

Studies on the Role of Some Fruit Trees in Carbon Storage

Currently, limited information exists regarding the carbon storage capacity of agricultural systems. This is due to a lack of data on the carbon content of orchard tree biomass[50]. By calculating the above-ground and below-ground biomass of trees using standard equations, important data can be generated regarding the ability of agricultural systems to mitigate the effects of climate change [51;52].As previously mentioned, carbon can be stored in plant roots, trunks, branches, leaves, flowers, and fruits. Elevated carbon dioxide levels have led to increased fruit yield and weight in some trees, highlighting the crucial role of fruit trees in reducing atmospheric carbon dioxide emissions. Fruit trees with well-developed flower and fruit structures possess the capacity to absorb and store significant amounts of carbon from the atmosphere. Aboveground and belowground biomass has been described as storing approximately 40% of carbon. Trees, including fruit trees, are considered a significant carbon source, estimated to absorb between 0.42 and 0.65 quintillion grams of carbon annually. This underscores the need for mixed farming or agroforestry practices for all types of fruit trees to sequester carbon and mitigate the effects of climate change[53;54].

In this context, numerous studies have been conducted on various fruit tree species, including date palms, apples, citrus fruits, grapes, olives, and stone fruits. The results indicate that the average carbon stock in oil palm orchards is 40.33 tons of carbon per hectare. The oil palm's structure contains the largest share of this carbon stock, at 53%. Oil palm trees are projected to store 4.55 tons of carbon per hectare annually [55]. Similar observations have been recorded in citrus, vine, apple, and olive orchards, where research has indicated the presence of a large stock of atmospheric carbon[56]. Navarro et al. [57]. [61] studied carbon sequestration in the vegetative parts of palm trees, calculating the amount of stored carbon at 16.1 mg of carbon per hectare per year. Ganiola and Marin [55]. also reported that mango trees, especially those 15 years old, are capable of absorbing larger amounts of carbon than other trees, reaching up to 45 mg of carbon per hectare per year. Oviantari et al. [58]. highlighted the role of tropical fruits and soil properties in carbon sequestration under agroforestry systems, finding a relationship between soil properties and soil organic carbon. They noted that a decrease in total nitrogen content leads to a decrease in soil organic carbon. Sharma et al. [6] also indicated that fruit and vine orchards accumulate large amounts of carbon due to their structure. According to a study on biocapacity of fruit trees (perennial plants considered natural carbon sequestrants), Rajan [42]. noted the ability of fruit trees to store large amounts of carbon and sequester carbon dioxide in agricultural ecosystems, such as black cherry, mango, grapefruit, bitter orange, sweet cherry, orange, and banana (Moussa). He emphasized their significant contribution to the global carbon cycle, climate regulation, and mitigation of global warming through the natural removal and sequestration of carbon from the atmosphere [4]. In a study by

[59]. on the role of mixed orchards in carbon sequestration and climate change mitigation, six biometric equations (M1-M6) were used, based on published studies and data from 49 orchards, to estimate the total tree biomass and carbon sequestration based on the carbon content of dry biomass. A species/geographical location equation (M1), a sex-specific equation (M2), a sex/geographical location equation for forests (M3), two general equations for measuring forest biomechanics (M4 and M5), and a general equation for agricultural landscapes (M6) were compared. The experimental results yielded averages of 15.42, 10.80, 11.39, 6.12, 6.66, and 9.88 megagrams of carbon per hectare, respectively. This indicates that organic and conventional orchards, at the same productive stage, did not differ significantly in carbon dioxide uptake (CO2seq) per tree annually (10.42 and 10 kg CO2eq, respectively). Equation M1 was considered the most representative (in terms of species and environment) for use in perennial Mediterranean orchards. Thus, the use of standard equations is proposed as a clear and efficient method for estimating carbon dioxide uptake from mixed orchards, based on the easily measurable biometric characteristics of the trees. These results are important for estimating carbon dioxide stocks in agricultural lands in the future.

Their findings also indicated that the highest carbon sequestration values in biomass were obtained in conventional orchards. This may be mainly due to the younger age of the trees in organic orchards (average tree age 11 years) compared to conventional orchards (average tree age 17 years), leading to a lower biomass in permanent plant structures and, consequently, a lower carbon content in the biomass[60]. A study by[61]. on fruit orchards of the same age group indicated that trees grown under organic farming conditions had a higher biomass than those grown under conventional farming.

Based on previous studies indicating the capacity and role of fruit trees in carbon sequestration, we emphasize the need to validate the models selected for field studies related to the carbon content of trees. This inevitably requires conducting experiments involving the collection of different samples in various environments.

Figure 3 illustrates a typical example of an apple tree and its contribution to carbon sequestration.

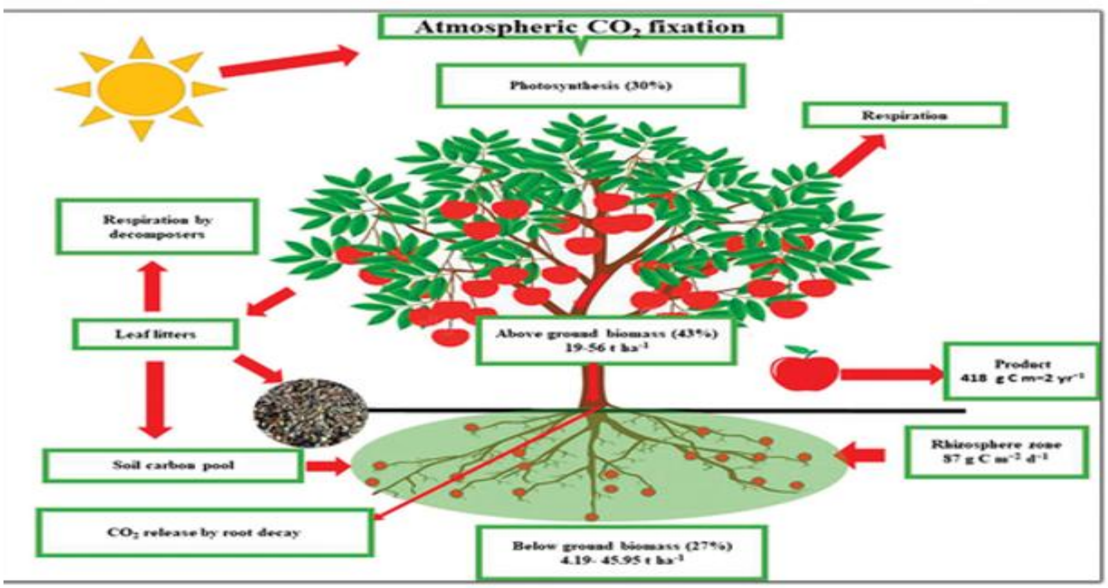

Figure 3. Typical example of an apple tree and its contribution to carbon sequestration.

Source: Lakso et al., [62].

Factors Affecting Carbon Sequestration

There are several factors affecting carbon sequestration in fruit crop such as:

1. Solar radiation:

It is one of the critical components in carbon sequestration because it involves photosynthesis. Carbon sequestration rates are significantly increased by solar radiation. Furthermore, it is involved in the carbon metabolism of fruit trees [63;64].

2. Temperature:

Temperature is a key physiological variable and has a direct impact on biological processes. Moderate temperature increases promote photosynthesis, while excessive heat can lead to increased rates of photorespiration and mitochondrial respiration, ultimately reducing net carbon uptake. It is worth noting that fruit trees accumulate less carbon at lower temperatures compared to higher temperatures, resulting in a larger carbon budget for fruit trees. [62;65].

3. Water and Arrogation:

Water is a contributor for photosynthesis, it induces leaf area that increases leaf density in trees, which is positively correlated with productivity. This indicates that under limited water supply, photosynthetic capability decreases, and thereby the amount of carbon absorbed and sequestered by foliage is decreased leaving a larger input of greenhouse gases from drought and water scarcity [66;67]. Studies have revealed the contribution of irrigation systems in mitigating greenhouse-gas emissions. Ye et al. [68]. observed that drip irrigation decreases the greenhouse-gas emissions enhancing denitrification (N) and methane (CH O) emissions such as resulted from the anaerobic decomposition of organic matter accumulates in flooded 34soils[63]. Also, the nitrous-oxide and methane emissions were decreased by sprinkler irrigation for 40% and over 99%, respectively [69;70].

4. Nutrient elements

They act on plant physiologies since the leaves have different concentrations of nutrients and each nutrient may have a different function, depending on the plant This complements the plant in photosynthesis and carbon uptake and sequestration [61;69;71].

Thus the contribution of fertilizers and natural nitrogen, carbon in soil are considered active role [72]. McSwiney and Robertson[73]. likewise observed an increment in soil moisture following nitrogen fertilization. Tenuta and Beauchamp[74]. demonstrated the role of soil conditions, for example that nitrous-oxide emissions were more present in aerobic soils following urea fertilization, while in saturated soils, at which these emissions were more evident following ammonium fertilization.

How to calculate the amount of carbon absorbed by trees

Trees have a crucial role in scavenging the carbon dioxide from the atmosphere. They become more efficient in carbon sequestration as they are getting older, which can contribute to climate change mitigation. Knowing how trees store carbon can also be used to work out the significance of actions to conserve or plant vegetation. Estimating how much carbon dioxide a tree has captured is also useful for estimating the trees environmental impact, and it can help encourage people and organizations to plant trees and keep them standing [75]. CO2 uptake process is highly linked to tree growth and its developmental dynamics, by the means of its impact on increase in the accumulation biomass (whole organic material that makes up the body of a tree). Aboveground biomass (AGB) consists of the vegetative and floral-fruit tree parts, whereas belowground biomass (BGB) refers to the roots system of a tree[76].

To calculate the volume of CO 2 absorbed by trees to be measured are taken from the tree directly, two simple measurements are taken, trunk diameter in centimeters and tree height in meters[77].

These biomass estimates are calculated according to a given formula following Shadman et al. [77].

$AGB = 0.25 \times D^2 \times H$

Where:

AGB: aboveground biomass

D: tree diameter measured at 1.37 m above the ground

H: tree height (in/ft).

Total vegetative biomass is estimated at 120% of AGB, using the concept that BGB (including root system) equals approximately less than 20% of AGB.

Therefore, BGB can be calculated as follows:

$BGB = 0.2 \times AGB$

Using these formulas, the total biomass of the tree can be calculated:

Total Biomass (TB) = AGB + BGB = AGB + 0.2 × AGB = 1.2 × AGB

On average, a tree consists of 72.5% dry matter and 27.5% moisture content."

To calculate the dry weight of the tree, as mentioned by De Sousa [78]. "the total biomass is multiplied by 72.5%:

Total Dry Weight (TDW) = TB × 0.725 "

As stated by Dulic, O., & Krkljes[79]. "Carbon constitutes 50% of the total dry weight. Accordingly:

Total Carbon (TC) = TDW × 0.5 "

Using the total carbon value, the equivalent amount of carbon dioxide stored in a tree can be calculated. Carbon dioxide has one carbon atom and two oxygen atoms. The atomic weight of C = 12 u, the atomic weight of O =16 u. The weight of the carbon dioxide in the trees is calculated as (the ratio of C to CO2 = 44/12 = 3.67). Thus, to find out how much carbon dioxide is stored in the tree we plug the mass of carbon in the tree into a formula with 3.67 as stated by) [74]. "

CO_2 weight = WC × 3.67 "

It is important to mention that the weight of carbon-dioxide stated above refers to CO_2 stored during the whole lifetime of the tree. The annual rates of CO2 sequestration was determined by dividing the total absorbed weight of CO_2 with

the age-of tree as 20.7:
CO_2 seq = W carbon-dioxide / age of tree (years) [74].
By using tree measurements with the equations provided, one can obtain a rough estimate of the carbon that can be sequestered..

Challenges and Future Directions

If we want to avoid the worst impacts of climate change, we must pursue strategies and technologies through which net greenhouse-gas emissions approach zero by the year 2050. This means extracting from the atmosphere as much carbon as we put into it. Formulating a standardized method of derivation of the greenhouse-gas budget or estimate of greenhouse- gas emission rate is thus necessary.

The contribution of the agricultural sector in mitigating greenhouse gases and in stabilizing (and perhaps even enhancing) carbon sequestration has been corroborated by numerous investigations and reviews. In this way, by following sustainable principles that align environmental goals with the practical requirements for food production, we are able to address the intricate relationship of societal need versus environmental stewardship and economic viability in agriculture within a climate changing

Overall, full assessments comprise integrating location specific information, compiling regional data, reporting and satellite-based information using relevant models. Careful manure management can also increase crop yield when integrated with tillage, irrigation and drainage. Apart from this, the growth of underground sensors further enriches ground-based observation to subsurface processes under vegetation cover and combined with remote sensing outcomes as well as data fusion techniques, monitorable datasets at high quality that have high spatial and temporal resolution can be produced to help us better understand ecosystem dynamics [80;81].

The US Senate considered some climate-change legislation in 2008, the Lieberman–Warner bill in particular. The bill suggested that agriculture should supply as much as 15% of the offsets required for a 71% greenhouse-gas reduction by 2050 from 2005 levels. However, this was not achieved in addressing future climate disruptions. Today, numerous proposals and projects have been introduced suggesting that by 2030, the agricultural sector could become free of greenhouse-gas emissions as well as increased soil carbon sequestration to counteract its emissions. “Whether these proposals or future legislation will more generally form the template for further refinement of future climate-change projects is yet to be seen, but it underlines that agriculture will have a role in this space [81].

The best tactics and practices to reduce greenhouse effects remain: Depend on renewable energy (prioritize these sources in order to decrease reliance on fossil fuels). Similarly, emphasis on climate-smart agricultural practices and promotion of sustainable practical agriculture can play a role in ensuring we have a more efficient approach in terms of limiting greenhouse-gas emissions [82;83].

In the near future, studies in carbon sequestration by fruit crops and sustainable environments will grow. Hence, models of fruit production should be calibrated with and integrated as predictive and methodological tools with the agricultural approaches.

Conclusion

Climate change is one of the most prominent problems exacerbated by human activities, particularly the burning of fossil fuels and deforestation. This poses threats and obstacles to sustainable development, as climate change impacts the environment, causing soil erosion, drought, desertification, biodiversity loss, flooding, and water pollution. Therefore, we must adapt to climate change and mitigate its effects by adopting carbon capture and storage (CCS) techniques in agriculture. This involves good agricultural practices capable of absorbing carbon dioxide from the atmosphere and storing carbon in plant biomass (roots, stems, branches, and leaves).

Fruit trees are one such strategy. They are multifunctional and contribute to food security, enhance resilience to climate change, and achieve sustainable development. Fruit trees are an important carbon sink, as their biomass contains significant amounts of stored carbon. By understanding how trees store carbon, we can estimate the amount of carbon dioxide they absorb. This not only allows us to measure the environmental impact that contributes to reforestation and tree survival, but also highlights the importance of landscaping with trees and preserving both trees and forests. The selection of fruit trees for planting should be based not only on their versatility but also on their economic viability. Therefore, multi-purpose fruit tree cultivation is crucial for environmental conservation. Consequently, selecting fruit trees based on their nutritional value and carbon sequestration capacity is both feasible and important for mitigating the effects of climate change and global warming. Fruit-based agroforestry systems, which integrate fruit tree cultivation with other plants, offer a promising alternative by enhancing ecosystem services and diversifying farmers' incomes. These strategies have been implemented for centuries in various environments. However, their widespread adoption in mitigating climate impacts and promoting sustainable agriculture remains under investigation. Therefore, it is essential to compile research and studies on the environmental, agricultural, social, and economic benefits of fruit-based agroforestry, examining its role in carbon sequestration, carbon absorption, biodiversity conservation, and economic diversification. Highlighting successful studies capable of identifying knowledge gaps,

Conflict of interest:

The author declares that there is no conflict of interest regarding the publication of this work

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دور أشجار الفاكهة في امتصاص واحتجاز الكربون: (مقالة)

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الخلاصة

تعد الزيادة السريعة في تركيز ثاني أكسيد الكربون (*CO2*) في الغلاف الجوي، إلى جانب الغازات الدفيئة الأخرى من المشاكل والتحديات التي تواجها البيئة نظرًا لتأثيرها في تغير المناخ. لذلك لابد من اتخاذ تدابير ووسائل فعالة للتخفيف من خطر التغير المناخي. من خلال ازالة الكربون من الغلاف الجوي اذ يُلتقط ثاني أكسيد الكربون الجوي ويُخزن في النباتات والتربة والمحيطات على شكل كتلة حيوية من خلال عملية التمثيل الضوئي. كما ان كفاءة عزل الكربون من خلال امتصاصه من مختلف النباتات بعملية التمثيل الضوئي وتخزينه على شكل كربون في الكتلة الحيوية للنبات والتربة وإدارتها في مختلف الأنظمة تختلف اختلافًا كبيرًا بسبب خصائصها الفسيولوجية ومعدلات النمو، وتراكم الكتلة الحيوية، والعوامل البيئية. وبهذا تستعرض هذه المقالة إمكانية أشجار الفاكهة بكونها مصدرًا هامًا في امتصاص وحجز الكربون في ظل التنمية المستدامة اذ تبين أن أشجار الفاكهة تخزّن كميات كبيرة من الكربون، تُضاهي إلى حدّ كبير مخزون الغابات. فضلا عن ذلك تتميز بساتين أشجار الفاكهة بخصائص هيكلية رائعة، مثل دورة حياتها الطويلة ومجموعها الخضري والجذري مما يعطيها الكفاءة العالية في عزل الكربون في الغلاف الجوي فضلا عن اختلاف كفاءة عزل الكربون باختلاف محاصيل الفاكهة وأنظمة إدارتها باختلاف أنماط نموها وتطورها، وسلوكها الفسيولوجي، وتراكم كتلتها الحيوية، والعوامل البيئية.

الكلمات المفتاحية: عزل الكربون, أشجار الفاكهة, البساتين, التخفيف من آثار تغير المناخ, الكربون العضوي في التربة.