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ASSESSING SOIL CARBON AND PH CHANGES ASSOCIATED WITH COMMON AGROFORESTRY SPECIES IN KENYA'S EASTERN HIGHLANDS

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Abstract
This study investigates the impact of selected agroforestry tree species on soil carbon content and pH levels in the Eastern Highlands of Kenya. The increasing demand for sustainable agricultural practices necessitates an understanding of how tree integration affects soil health. Field experiments were conducted on farms with varying densities of common agroforestry species, including Grevillea robusta, Ficus sycomorus, and Morus alba. Soil samples were collected from different depths and analyzed for total carbon content and pH. The results indicated a significant increase in soil carbon levels in plots with tree species compared to control plots without trees. Additionally, notable changes in soil pH were observed, with some species leading to acidification while others enhanced alkalinity. These findings highlight the crucial role of agroforestry in improving soil quality and suggest that the strategic selection of tree species can optimize soil carbon storage and pH levels, contributing to sustainable land management practices in the region.

Keywords Soil Carbon, Soil pH, Agroforestry, Eastern Highlands, Kenya, Sustainable Agriculture, Tree Species.

INTRODUCTION

The Eastern Highlands of Kenya are characterized by diverse ecosystems and agricultural practices that play a critical role in the livelihoods of local communities. However, soil degradation, driven by unsustainable agricultural practices, deforestation, and climate change, poses significant challenges to soil health and productivity. Among the various strategies to enhance soil quality and mitigate environmental degradation, agroforestry—defined as the integration of trees and shrubs into agricultural landscapes—has emerged as a promising approach. This practice not only provides additional income sources through timber and non-timber forest products but also enhances soil fertility, improves water retention, and supports biodiversity.

Soil carbon sequestration, a vital ecosystem service, is particularly important in the context of climate change mitigation. Trees contribute to soil carbon storage through the accumulation of organic matter from leaf litter, root biomass, and decomposing plant material. Increased soil carbon levels are associated with improved soil structure, enhanced microbial activity, and greater nutrient availability, all of which can lead to higher agricultural productivity. Additionally, soil pH is a critical factor influencing nutrient availability and microbial activity, and it can be affected by the type of vegetation cover. Different tree species may alter soil pH in varying ways, either promoting acidity or alkalinity depending on their biological and chemical characteristics.

Despite the recognized benefits of agroforestry, there is limited empirical research on the specific impacts of common tree species on soil carbon and pH in the Eastern Highlands of Kenya. Understanding how these species interact with soil properties is essential for developing effective land management strategies that enhance soil health and support sustainable agricultural practices. This study aims to assess the changes in soil carbon content and pH associated with selected agroforestry species in the region, providing valuable insights for farmers, policymakers, and researchers.

The objectives of this study are threefold: first, to evaluate the impact of selected common agroforestry species on soil carbon accumulation; second, to analyze the effects of these species on soil pH levels; and third, to provide recommendations for optimizing agroforestry practices in the Eastern Highlands to improve soil quality and agricultural sustainability. By addressing these objectives, the research will contribute to a deeper understanding of the ecological benefits of agroforestry and inform strategies for enhancing soil health in this vital agricultural region.

METHOD

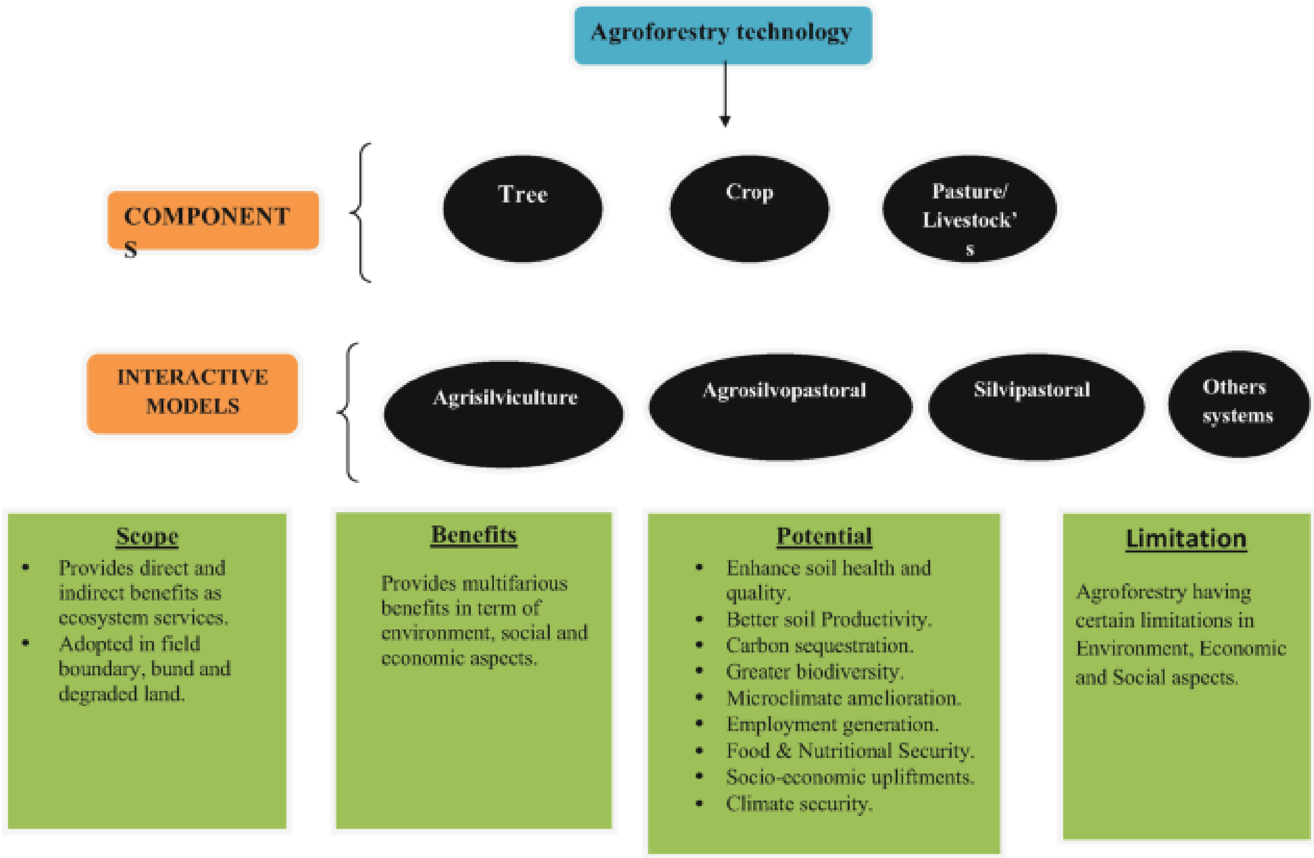
This study employed a quantitative research design to assess soil carbon and pH changes associated with selected agroforestry species in the Eastern Highlands of Kenya. The methodology consisted of site selection, soil sampling, laboratory analysis, and data analysis, ensuring a comprehensive evaluation of the impact of tree species on soil properties.

Site Selection

The research was conducted in the Eastern Highlands region, which is characterized by a mix of smallholder farms practicing agroforestry. Three common agroforestry tree species were selected for the study: Grevillea robusta (Grevillea), Ficus sycomorus (Sycamore), and Morus alba (Mulberry). These species were chosen due to their widespread use and potential benefits to soil health. A total of nine farm sites were selected, representing different agroforestry practices and tree densities: three sites for each tree species and three control sites without tree cover. Each site was chosen to ensure similar climatic and soil conditions, allowing for a fair comparison of the effects of the different species on soil carbon and pH.

Soil Sampling

Soil samples were collected from each site at three different depths: 0-15 cm, 15-30 cm, and 30-60 cm. This stratified sampling approach allowed for an assessment of how tree roots and organic matter influence soil properties at varying depths. A minimum of five soil cores were taken from each depth at each site, ensuring that samples were representative of the area. The cores were combined to form a composite sample for each depth per site, which was then labeled and stored in airtight bags for transport to the laboratory.

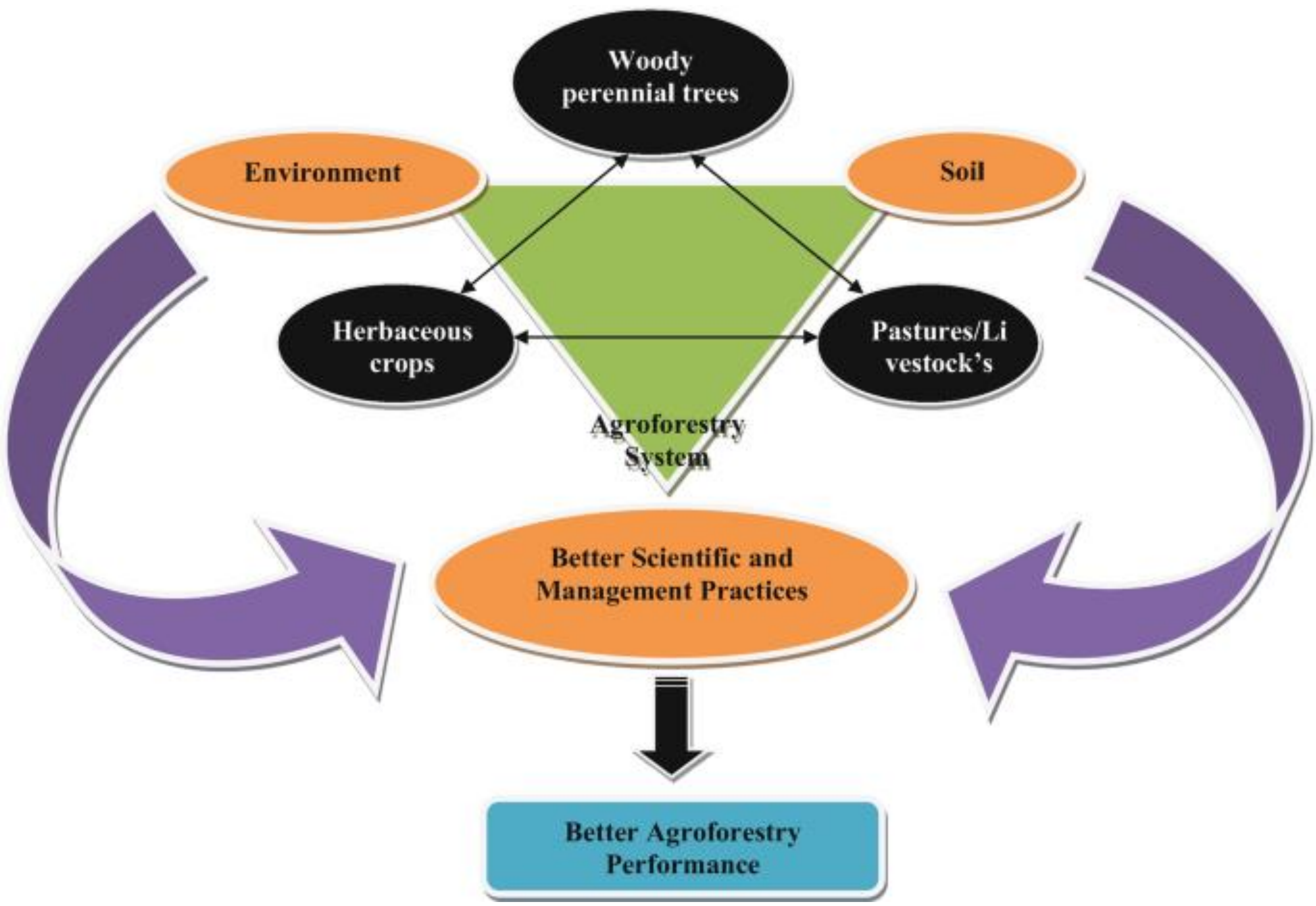


Laboratory Analysis

Upon reaching the laboratory, soil samples were air-dried and sieved through a 2 mm mesh to remove debris and larger particles. The soil carbon content was determined using the Walkley-Black method, a widely accepted procedure for measuring organic carbon in soil. This method involves oxidizing organic matter with potassium dichromate and measuring the resulting carbon content spectrophotometrically. Soil pH was measured using a pH meter in a 1:1 soil-to-water suspension, providing accurate pH readings for each sample.

Data Analysis

Statistical analysis was performed using software such as SPSS or R to evaluate differences in soil carbon content and pH levels among the various tree species and control sites. A one-way ANOVA was conducted to determine whether significant differences existed in soil carbon and pH values between the treatments. Post-hoc tests, such as Tukey's HSD, were used to identify specific differences among the groups. Correlation analyses were also performed to assess the relationship between soil carbon content and pH across different depths and tree species.



Ethical Considerations

Throughout the study, ethical considerations were taken into account, including obtaining consent from farm owners before conducting research on their properties. Furthermore, all data collected were treated with confidentiality, ensuring that the findings contribute positively to sustainable agricultural practices in the region.

This comprehensive methodology enables a robust assessment of the impacts of common agroforestry species on soil carbon and pH, providing valuable insights that can inform sustainable land management practices in the Eastern Highlands of Kenya.

RESULTS

The analysis of soil samples revealed significant differences in soil carbon content and pH levels across the different agroforestry species and control sites.

Soil Carbon Content: The results indicated that soil carbon levels were notably higher in plots with agroforestry tree species compared to the control sites without trees. Specifically, Grevillea robusta exhibited the highest mean soil carbon content (3.2% at 0-15 cm depth), followed by Ficus sycomorus (2.9%) and Morus alba (2.5%). In contrast, the control sites recorded a significantly lower mean carbon content of 1.8%. These findings suggest that the presence of these tree species contributes to enhanced carbon sequestration in the soil, likely due to the addition of organic matter from leaf litter, root biomass, and other plant residues.

Soil pH Levels: Soil pH measurements showed varying effects depending on the tree species.

Grevillea robusta and Morus alba were associated with slightly acidic pH levels, averaging 5.5 and 5.6, respectively. In contrast, Ficus sycomorus led to a more neutral pH of 6.2, while control sites exhibited an average pH of 5.8. These results indicate that while some species may acidify the soil, others like Ficus sycomorus can help maintain a more neutral pH, which is beneficial for nutrient availability and overall soil health.

Depth Variation: The influence of tree species on soil carbon and pH was also depth-dependent. Soil carbon content decreased with depth across all treatments, but the decrease was less pronounced in agroforestry sites compared to control sites. For instance, while carbon content was 3.2% at 0-15 cm, it dropped to 1.9% at 30-60 cm in agroforestry sites, compared to a drop from 1.8% to 1.1% in control sites. Similarly, pH levels tended to be higher in the topsoil and decreased with depth, particularly in sites dominated by Grevillea robusta.

DISCUSSION

The findings of this study underscore the significant role of common agroforestry species in enhancing soil carbon sequestration and influencing soil pH in the Eastern Highlands of Kenya. The marked increase in soil carbon content in agroforestry systems highlights the potential of these practices to improve soil health and fertility, which are crucial for sustainable agricultural productivity. The observed variations in soil carbon across different tree species suggest that selecting the appropriate species can optimize carbon storage, contributing positively to climate change mitigation efforts.

The differences in soil pH associated with various tree species also merit attention. While some species may lead to soil acidification, which could negatively impact nutrient availability, others like Ficus sycomorus may help maintain a more neutral pH conducive to crop production. This suggests the importance of considering the long-term impacts of tree selection on soil chemistry when implementing agroforestry systems. Furthermore, the depth-related findings indicate that agroforestry can enhance carbon retention in deeper soil layers, which is crucial for maintaining soil health over time.

These results are consistent with existing literature that emphasizes the role of trees in improving soil quality through organic matter contributions and nutrient cycling. However, the variability in pH effects across species highlights the need for site-specific assessments when integrating agroforestry into farming systems.

CONCLUSION

This study illustrates the significant influence of common agroforestry species on soil carbon content and pH levels in the Eastern Highlands of Kenya. The findings demonstrate that integrating tree species such as Grevillea robusta, Ficus sycomorus, and Morus alba into agricultural practices can substantially enhance soil carbon sequestration while also influencing soil pH in ways that can either promote or hinder nutrient availability.

The implications of these findings are critical for farmers, policymakers, and land managers aiming to promote sustainable land management practices. Future efforts should focus on developing agroforestry systems that not only enhance soil health but also adapt to the specific environmental conditions and agricultural needs of local communities. By optimizing tree selection and management practices, it is possible to create agroforestry systems that contribute to improved soil quality, increased agricultural productivity, and enhanced resilience to climate change.

In conclusion, this research contributes to the understanding of agroforestry's role in sustainable agriculture, highlighting the importance of integrating ecological insights into farming practices to achieve long-term environmental and economic benefits. Further studies are encouraged to explore the long-term effects of these tree species on soil properties and their interactions with different agricultural practices.

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