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Seasonal variation in biomass production and carbon stock under Semialata (*Flemingia semialata*): Based agroforestry systems

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Abstract

The present study evaluated the influence of different sole and Semialata-based agroforestry systems on total biomass, total carbon stock, and soil carbon stock across summer, rainy, and winter seasons. The results revealed that cropping systems significantly ($p < 0.05$) affected biomass production and carbon accumulation. In summer and rainy seasons, okra and cucurbit-based systems recorded maximum total biomass and carbon stock, whereas in winter, spinach and leguminous crops such as faba bean and French bean showed superior performance. Soil carbon stock also varied significantly among treatments, with high-biomass crops such as bitter melon and okra in summer and rainy seasons, and French bean and other legumes in winter, contributing to greater soil organic carbon. Increased residue returns and root biomass enhanced carbon input to soil. The perennial shrub Semialata provided continuous litter fall and root turnover, while seasonal intercrops—particularly legumes—further improved organic matter addition and carbon stabilization. Overall, the findings demonstrate that appropriate seasonal crop selection in Semialata-based agroforestry systems enhances biomass productivity and strengthens carbon sequestration potential.

Keywords: Semialata-based agroforestry system, biomass production, carbon sequestration, soil carbon stock

Introduction

Climate change mitigation through biological carbon sequestration has become a major focus of sustainable land-use systems. Agroforestry, which integrates trees and shrubs with crops and/or livestock, enhances carbon storage in biomass and soil while maintaining agricultural productivity. Compared to monocropping systems, agroforestry systems accumulate higher aboveground biomass and improve soil organic carbon (SOC) through litter deposition, root turnover, and reduced soil disturbance. Among shrub-based agroforestry species, *Flemingia semialata* (commonly known as Semialata) plays a dual ecological and economic role. It is a perennial leguminous shrub widely cultivated in eastern and central India and is an important lac host plant for the cultivation of lac insects (*Kerria* spp.). Due to its suitability for lac production, adaptability to marginal lands, and rapid biomass growth, Semialata has become an integral component of lac-based agroforestry systems as a nitrogen-fixing shrub; Semialata improves soil fertility and contributes organic matter through continuous leaf fall and root biomass addition. Its woody stem and root system store carbon in aboveground and belowground pools, while litter inputs enhance soil organic carbon. In lac-based systems, the regular pruning and regrowth cycles further influence biomass accumulation and carbon dynamics. Despite its economic importance as a lac host plant, limited scientific attention has been given to quantifying carbon stocks under Semialata-based agroforestry systems. Understanding its biomass carbon and soil carbon contributions is essential for evaluating its role in climate change mitigation and promoting sustainable lac-based agroforestry in rainfed and tribal regions.

Materials and Methods

The biomass production and carbon stock of the intercrops was evaluated in three seasons (summer, rainy and winter) with seven treatments layout in RBD design at farm of ICAR NISA (formerly ICAR IINRG). Biomass and carbon stock of semialata was studied only at the time of harvesting of lac *i.e.*, during winter season due to the non-availability of allometric biomass equation for semialata and non-suitability of using destructive method. The selected crops within a plot were uprooted and cleaned to remove intact soil from the roots. The shoot and root portion of the crop were separated and put in paper bags after cleaning. The paper bags were kept in the oven for drying and oven dried at 65 ± 5 °C to a constant weight. For converting biomass to carbon stock of the crop, the biomass is multiplied by a default value given by IPCC. The soil carbon stock for each cropping systems was also evaluated in three seasons. Soil sampling was done within each clustered plot by digging profiles up to 0-15 cm at the time of harvesting of crops. Composite samples from all sub area were obtained for the selected depth. Samples were air dried in shade, grinded in wooden pestle, passed through 2 mm sieve and stored in cloth bags for analysis of organic carbon (Wet digestion method by Walkley and Black, 1934) [9] and bulk density (Specific gravity method by Singh, 1980) [8]. Soil carbon stock (t/ha) was calculated by using formula (Nelson and Sommers, 1996) [5].

Soil carbon stock (t/ha) = [Soil bulk density (g cm⁻³) × Soil depth (cm) × Carbon]

Results and Discussion

Evaluation of biomass and carbon stock potential under the different cropping system for summer, rainy and winter season

The study showed that different cropping system had significantly influenced the total biomass and total carbon stock (Table 1, 2&3). In summer season, significantly ($p < 0.05$) maximum total biomass and total carbon stock were observed in okra followed by semialata+okra, bittergourd, bottlegourd,

semialata+bottlegourd, semialata+bittertgourd. Significantly ($p < 0.05$) maximum total biomass and total carbon stock were recorded in okra, followed by semialata+okra, radish, tomato, semialata+tomato, semialata+radish in rainy season. In winter season, significantly ($p < 0.05$) maximum total biomass and total carbon stock were recorded in spinach followed by fababean, semialata+spinach, semialata+fababean, semialata+french bean.

The seasonal variation in total biomass and total carbon stock across sole and intercropping treatments reflects the influence of crop growth characteristics and climatic suitability. During summer, the significantly ($p < 0.05$) higher total biomass and carbon stock observed in okra, Semialata + okra, bitter gourd, bottle gourd, Semialata + bottle gourd, and Semialata + bitter gourd may be attributed to the vigorous growth and high photosynthetic efficiency of these warm-season crops. Okra and cucurbits produce substantial aboveground biomass under high temperature and radiation, leading to greater carbon accumulation (Amin *et al.*, 2023; Schaffer *et al.*, 2017) [2, 7]. In the rainy season, the significantly higher biomass and carbon stock recorded in okra, Semialata + okra, radish, tomato, Semialata + tomato, and Semialata + radish can be explained by enhanced moisture availability that promotes rapid vegetative growth and root development, thereby increasing both aboveground and belowground carbon pools. During winter, the significantly highest biomass and carbon stock observed in spinach, faba bean, Semialata + spinach, Semialata + faba bean, and Semialata + french bean highlights the suitability of leafy and leguminous crops under cooler conditions. Legumes further contribute to carbon stock through biological nitrogen fixation and greater root biomass incorporation (Kebede, 2021) [4]. The perennial woody component, *Flemingia semialata*, enhances overall system carbon storage by providing continuous litter fall and root turnover, while intercrops increase seasonal biomass inputs. These findings reinforce that appropriate crop selection according to season significantly enhances total biomass production and carbon sequestration potential in Semialata-based agroforestry systems.

Table 1: Biomass production and carbon stock under different cropping system in summer season

Cropping system	Above ground Biomass (t/ha)		Below ground biomass (t/ha)		Total biomass (t/ha)		Total Carbon stock (t/ha)	
	Sole	Intercrop	Sole	Intercrop	Sole	Intercrop	Sole	Intercrop
Semialata	-		-		-		-	
Okra	3.87		0.96		4.83		2.42	
Bitter gourd	1.48		0.10		1.58		0.79	
Bottle gourd	0.55		0.05		0.60		0.30	
Semialata+Okra		3.57		0.98		4.55		2.27
Semialata+Bitter gourd		0.32		0.03		0.35		0.17
Semialata+Bottle gourd		0.53		0.05		0.58		0.29
CD 0.05		1.47		0.21		1.66		0.83

Table 2: Biomass production and carbon stock under different cropping system in rainy season

Cropping system	Above ground Biomass (t/ha)		Below round biomass (t/ha)		Total biomass (t/ha)		Total Carbon stock (t/ha)	
	Sole	Intercrop	Sole	Intercrop	Sole	Intercrop	Sole	Intercrop
Semialata	-		-		-		-	
Okra	0.78		0.18		0.96		0.48	
Tomato	0.30		0.08		0.30		0.19	
Radish	0.16		0.40		0.56		0.28	
Semialata+Okra		0.61		0.13		0.75		0.37
Semialata+Tomato		0.23		0.06		0.29		0.15
Semialata+Radish		0.08		0.13		0.22		0.11
CD 0.05		0.06		0.03		0.07		0.04

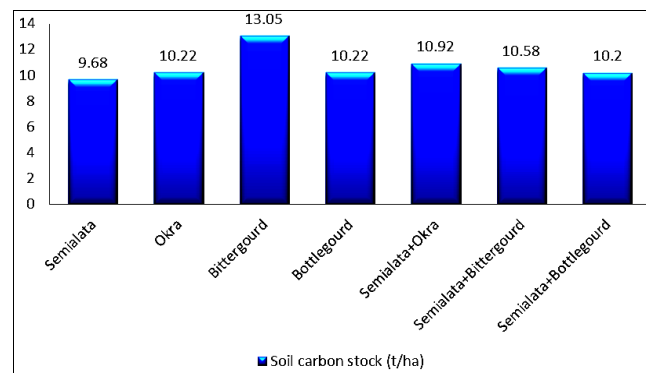
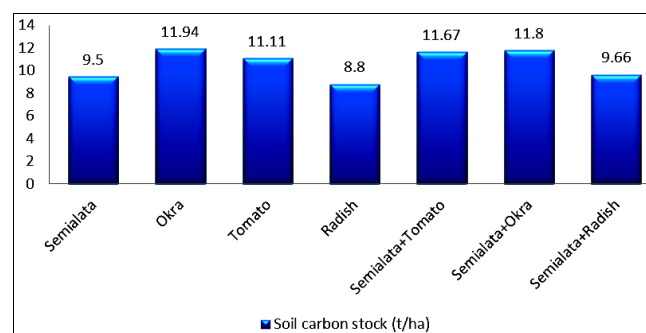
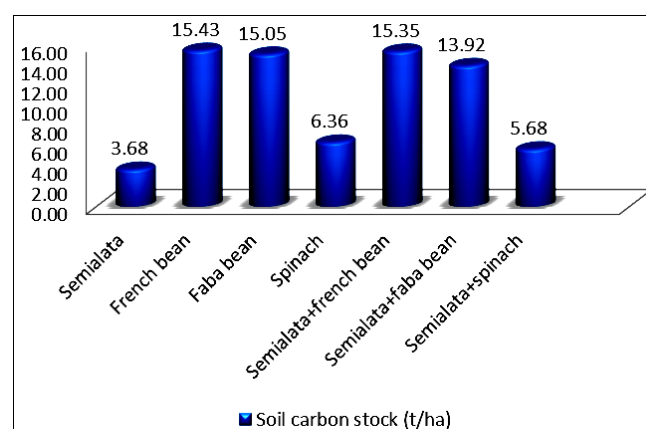
Table 3: Biomass production and carbon stock under different cropping system in winter season

Cropping system	Above ground Biomass (t/ha)		Below ground biomass (t/ha)		Total biomass (t/ha)		Total Carbon stock (t/ha)	
	Sole	Intercrop	Sole	Intercrop	Sole	Intercrop	Sole	Intercrop
Semialata	-		-		-		-	
French bean	0.36		0.09		0.45		0.23	
Fababean	1.72		0.16		1.88		0.94	
Spinach	2.03		0.77		2.80		1.40	
Semialata+French bean		0.33		0.06		0.39		0.20
Semialata+Faba bean		1.02		0.11		1.13		0.57
Semialata+Spinach		1.07		0.35		1.42		0.71
CD 0.05	0.28		0.14		0.42		0.21	

The result revealed that different cropping system had significantly influenced the soil carbon stock (Fig.1,2 &3). The maximum soil carbon stock was recorded in bittergourd followed by semialata+okra, semialata+bittergourd, bottlegourd, okra, semialata+bottlegourd, semialata in summer season. In rainy season, the significantly ($p < 0.05$) maximum soil carbon stock was recorded sole cropping okra followed by semialata+tomato, semialata+okra, tomato, semialata+radish, semialata, radish. In winter season, the maximum soil carbon stock was recorded in sole french beans followed by semialata+french beans, fababean, semialata+fababean, spinach semialata+spinach, semialata.

Bittergourd, Semialata + okra, Semialata + bitter gourd, bottle gourd, okra, Semialata + bottlegourd, and sole Semialata, suggests that high-biomass cucurbit crops contribute substantial organic residues and root biomass to the soil. The spreading growth habit and extensive root systems of bitter gourd and bottle gourd likely enhanced belowground carbon inputs, thereby increasing SOC levels. In the rainy season, the significantly ($p < 0.05$) highest soil carbon stock under sole okra, followed by Semialata + tomato, Semialata + okra, tomato, Semialata + radish, Semialata, and radish, may be attributed to rapid vegetative growth under adequate moisture conditions, leading to higher litter fall and root turnover. In winter, the maximum soil carbon stock observed in sole french beans, followed by Semialata + French beans, faba bean, Semialata + faba bean, spinach, Semialata + spinach, and Semialata, highlights the important role of leguminous crops in enhancing SOC through biological nitrogen fixation, improved root biomass, and greater residue incorporation. Similar findings have been reported in vegetable-based and intercropping systems, where higher biomass-producing crops significantly increased SOC through greater residue return and root-derived carbon inputs (Blanco-Canqui and Lal, 2009; Albrecht and Kandji, 2003) [3, 1]. Root biomass contribution to soil carbon pools and the importance of rhizodeposition in carbon stabilization have also been emphasized by Pausch and Kuzyakov, 2018 [6]. Furthermore, studies on diversified cropping systems have shown that crops with extensive canopy and root architecture enhance soil carbon sequestration compared to low-biomass crops

The perennial shrub component, *Flemingia semialata*, contributes continuous litter and root biomass across seasons; however, the addition of seasonal crops—particularly legumes—further enhances organic matter input and soil carbon stabilization. These results support earlier findings that diversified agroforestry and intercropping systems improve soil carbon stocks compared to monocropping due to complementary root distribution, higher biomass return, and improved soil microclimatic conditions.

**Fig 1:** Soil carbon stock under different cropping system in summer season**Fig 2:** Soil carbon stock under different cropping system in rainy season**Fig 3:** Soil carbon stock under different cropping system in winter season

Conclusion

The results indicate that Semialata-based intercropping systems significantly enhance total biomass, carbon stock, and soil

organic carbon across seasons. High-biomass vegetables in summer and rainy seasons, and leafy and leguminous crops in winter, contributed substantially to carbon accumulation. The perennial shrub component, *Flemingia semialata*, ensured continuous carbon input through litter and root turnover. Overall, seasonal crop diversification with Semialata improves productivity and strengthens carbon sequestration potential in agroforestry systems.

References

1. Albrecht A, Kandji ST. Carbon sequestration in tropical agroforestry systems. *Agric Ecosyst Environ.* 2003;99(1-3):15-27.
2. Amin MHA, Akter MM, Jutidamrongphan W, Techato KA. Okra tree crop agroforestry model: economic and environmental impact. *Environ Dev Sustain.* 2023;25(11):12527-12542.
3. Blanco-Canqui H, Lal R. Crop residue management and soil carbon dynamics. *Soil carbon sequestration and the greenhouse effect.* 2009;57:291-309.
4. Kebede E. Contribution, utilization, and improvement of legumes-driven biological nitrogen fixation in agricultural systems. *Front Sustain Food Syst.* 2021;5:767998.
5. Nelson DW, Sommers LE. Total carbon, organic carbon, and organic matter. In: Page AL, Miller RH, Keeney DR, editors. *Methods of soil analysis: Part 2 chemical and microbiological properties.* 2nd ed. Madison: American Society of Agronomy; 1982. p. 539-579.
6. Pausch J, Kuzyakov Y. Carbon input by roots into the soil: quantification of rhizodeposition from root to ecosystem scale. *Glob Change Biol.* 2018;24(1):1-12.
7. Schaffer AA, Pharr DM, Madore MA. Cucurbits. In: Zamski E, Schaffer AA, editors. *Photoassimilate distribution in plants and crops: source-sink relationships.* New York: Routledge; 2017. p. 729-758.
8. Singh RA. *Soil physical analysis.* New Delhi: Kalyani Publishers; 1980.
9. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 1934;37:29-38.