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Assessing Soil Fertility Dynamics and Carbon Sequestration Potential in Groundnut (*Arachis hypogaea L.*) Cultivation Areas of Sri Satya Sai District, Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author SLG designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors LSP, ND and SR managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

In 2021-2022, a study was conducted at the Agricultural Research Station in Anantapur, Andhra Pradesh, India, focusing on soil fertility changes and carbon storage potential in Sri Satya Sai district. A total of 300 soil samples were collected, 150 before and 150 after groundnut (*Arachis*

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hypogaea L.) cultivation in three blocks (i.e., Chennekothapalle, Ramagiri, and Roddam) of Sri Satya Sai District, Andhra Pradesh, India. Chennekothapalle exhibited a decline in pH from 6.83 to 6.53 after groundnut (*Arachis hypogaea L.*) cultivation, accompanied by a decrease in electrical conductivity (EC) levels from 0.22 to 0.18. Similarly, Ramagiri displayed a similar trend with a drop in pH from 7.03 to 6.63 and a decrease in EC from 0.22 to 0.20 dS/m. Roddam experienced a slight reduction in pH from 6.52 to 6.48 and a decrease in EC from 0.18 to 0.16 dS/m. Organic carbon (OC) content showed varying trends, with notable increases in Chennekothapalle (from 0.44% to 0.94%), Ramagiri (from 0.43% to 1.13%), and Roddam (from 0.3054% to 0.4454%) after cultivation. Nitrogen levels witnessed an increase in all three blocks, Chennekothapalle rising from 141.3 to 171.3 kgs/ha, Ramagiri from 162.11 to 192.11 kgs/ha, and Roddam from 129.44 to 154.44 kgs/ha. Additionally, Posphorus levels increased in Chennekothapalle (from 16.76 to 19.76 kgs/ha), Ramagiri (from 13.62 to 18.62 kgs/ha), and Roddam (from 30.24 to 35.24 kgs/ha) after cultivation. Similarly, Potassium levels showed increases in Chennekothapalle (from 159.07 to 184.07 kgs/ha), Ramagiri (from 161.04 to 195.04 kgs/ha), and Roddam (from 154.49 to 174.49 kgs/ha), indicating distinct patterns of soil fertility dynamics across these regions. In Chennekothapalle, the soil organic carbon content (TOC) increased from 0.004% to 0.009%, and there was a substantial rise in soil carbon stock (SCS) from 18.11 to 39.37 kgs/m². Carbon turnover, measured through mean CO2 levels, increased from 160.45 gms to 343.7 gms, and the Carbon Sequestration Potential (CSP) was 6900 Kgs. In Ramagiri, TOC saw an increase from 0.004% to 0.011%, with SCS improving from 30.92 to 37.38 kgs/m², indicating greater soil carbon storage. A significant rise in CO2 levels from 158.69 gms to 415.3 gms was observed, and CSP was 7700 Kgs. In Roddam, TOC increased from 0.003% to 0.004%, and SCS rose from 20.24 to 30.06 kgs/m², signaling improved soil carbon stocks. CO2 levels increased from 111.98 gms to 163.3 gms, reflecting enhanced carbon turnover, and remarkably, CSP was 3150 Kg. In comparing the three blocks, it's evident that Ramagiri exhibited the most substantial increase in soil fertility and carbon sequestration potential. While Chennekothapalle is showing significant improvements, Roddam experienced relatively modest changes in all parameters.

Keywords: Soil fertility; soil organic carbon sequestration; available nitrogen; available phosphorus; available potassium.

1. INTRODUCTION

Soil fertility and carbon sequestration are integral components of sustainable agriculture, essential for shaping the future of food production and environmental preservation. Soil fertility, which encompasses the availability of vital nutrients, organic matter richness, and the bustling activity of beneficial microbes, forms the bedrock of agricultural productivity, wielding profound influence over crop yields and quality. It is the key component for global food security, ensuring that agricultural systems can rise to meet the escalating demands of a burgeoning global population. It plays a pivotal role in ensuring global food security by meeting the demands of a growing world population [1,2] and Soil fertility, the ability of soil to support plant growth, is vital for food production as the world's population grows. However, natural and human-induced factors can disrupt soil fertility. Population growth, intensive farming, and improper use of fertilizers can deplete soil nutrients and quality [3].

Groundnut (*Arachis hypogaea L.*), an important cash crop grown mostly by smallholder farmers, has a complex relationship with soil fertility and the agricultural industry. It has a high local demand as well as export possibilities. Groundnut, as a legume, can fix atmospheric nitrogen in the soil. According to studies, if groundnut is grown in rotation with maize, the production of maize is enhanced by 20% due to groundnut's capacity to fix atmospheric nitrogen. It also contributes to the ecosystem's long-term sustainability. If the entire plant is uprooted, groundnut is regarded a soil depleting crop; but, if the vines and leaves are returned to the soil, groundnut is considered a soil improving crop [4]. Mulching with crushed nut shells is another common approach for retaining soil moisture and improving soil health.

Soil fertility and the analysis of nutrients are fundamental pillars of sustainable agriculture [3]. Soil fertility, defined as the soil's capacity to support plant growth, is a cornerstone of global food production and agricultural sustainability. The assessment and management of nutrient levels in soil play a pivotal role in optimizing crop yields, improving crop quality, and safeguarding the long-term health of our soils [5]. Soil analysis, a key component of modern agricultural practices, offers valuable insights into critical soil parameters. These parameters include nutrient content, pH levels, organic matter content, and the presence of beneficial or detrimental microorganisms. Such information is vital for tailoring fertilizer applications, making informed decisions about soil amendments, and implementing sustainable land management practices [3].

Simultaneously, the rapid decline of soil carbon in tropical soils is a cause for concern, as soil carbon is a crucial indicator of ecosystem health. Soil plays a vital role in the global carbon cycle, serving as a reservoir for organic carbon and a carbon dioxide sink. More than 60% of the world's soil carbon resides in the soil itself, with an additional 20% in the atmosphere as carbon dioxide [6]. Forest ecosystems, in particular, store a significant portion of terrestrial carbon [7]. The carbon sequestration in soils, the process of capturing and storing atmospheric carbon dioxide, emerges as a potent tool in combating climate change. This process not only mitigates greenhouse gas emissions, a leading cause of climate change but also enhances soil structure, fertility, and water retention, contributing to a more resilient and healthier environment [8,2]. However, the conversion of native ecosystems, such as forests and grasslands, into agricultural lands and ongoing plant material harvesting have led to significant losses of plant biomass and carbon. This has contributed to the rise in atmospheric carbon dioxide levels, exacerbating climate change [9]. Native forest conversion is often followed by a decline in soil organic carbon and soil structure deterioration.

In the groundnut (*Arachis hypogaea L.*) cultivation areas of Sri Satya Sai District, Andhra Pradesh, India, the research focuses on soil fertility and carbon sequestration. It aims to understand the soil's health by studying nutrients, pH levels and primary nutrients like Nitrogen, Phosphorus and Potassium. Additionally, the goal is to measure how much carbon, the soil can store and find ways to increase this capacity. The ultimate objective is to provide practical, sustainable land management recommendations that improve soil quality, boost crop yields, and contribute to fighting climate change. This research aims to make a significant impact on local agriculture and environmental sustainability.

2. MATERIALS AND METHODS

2.1 Study Area

The study area, Sri Satya Sai District (Puttaparthi), is situated between Northern Latitudes 13°-40' to 14°-6' and Eastern Longitudes 76°-88' to 78°-30'. Geographically, it shared its borders with Ananthapuramu District to the North, YSR Kadapa District, and Chittoor District to the East, and the state of Karnataka to the West and Southwest. This region experiences a typical temperature range, with minimum temperatures hovering around 22.9°C and maximum temperatures reaching approximately 34°C. The average annual rainfall in this area is approximately 556 mm. Administratively, Sri Satya Sai District was divided into four divisions and encompasses a total of 32 blockss. For the purpose of our research study, our focus was on the Chennekothapalle, Ramagiri, and Roddam blockss within the district.

2.2 Soil Collection

A total of 300 soil samples were collected, 150 before and 150 after groundnut (*Arachis hypogaea L.*) cultivation in three blocks, with 50 samples from each blocks. These samples were specifically taken from soil associated with groundnut (*Arachis hypogaea L.*) crop cultivation, both before and after the crop was grown. With the help of Khurpi, Spade, and a meter scale the soil samples were collected randomly from a depth of 30cm. After collection, the soil samples were air-dried and sieved to a size greater than 2 mm.

2.3 Statistical Analysis

The t-test, also known as Student's t-test was invented by William Sealy Gosset used for to compare the means of two groups to determine if there is a statistically significant difference between them [17].

$$t\ test = \frac{x1 - \bar{x}_2}{\sqrt{s2\left(\frac{1}{n1} - \frac{1}{n2}\right)}}$$

In this formula, t is the t value, x1 and x2 are the means of the two groups being compared, s2 is the pooled standard error of the two groups, and n1 and n2 are the number of observations in each of the groups.

List 1. Methods used for Soil analysis

S.No	Particulars	Method
1	Bulk Density (Mg m-3)	100ml measuring cylinder by Muthuaval method [10]
2	pH	1:2 soil water suspensions using digital pH meter by Jackson [11]
3	Electrical Conductivity (1: 2.5)	1:2 soil water suspensions using digital electrical conductivity meter by Wilcox [12]
4	Organic Carbon (%)	Rapid titration method by Walkley and Black method [13]
5	Available Nitrogen (kg ha-1)	Alkaline potassium permanganate by Subbiah and Asija [14]
6	Available Phosphorus (kg ha-1)	Photoelectric Colorimeter by Olsen method [15]
7	Available Potassium (kg ha-1)	Flame Photometer by Toth and Prince method [16]

Carbon Sequestration (g C m-2) was calculated using the method of [7] BD (g cm-3) x OC (g kg-1) x horizon thickness (depth) (cm) ≈ $\sum$Bi x Ci x Di where Bi is the bulk density of individual layer i (g cm-3), Ci is organic carbon in layer (g kg-1) and Di is the thickness of this layer (cm).

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Properties

3.1.1 pH

The pH levels in Chennekothapalle showed a decrease from a mean of 6.83 before the cultivation of the groundnut (*Arachis hypogaea L.*) crop to 6.53 after the cultivation of the groundnut crop (*Arachis hypogaea L.*). The minimum and maximum pH values were 4.92 and 7.85, respectively, with a standard deviation (SD) of 0.54. The t-test results indicated statistical significance (p = 0.0067), suggesting that the treatment had a notable impact on soil pH. In Ramagiri, there was a decrease in mean pH from 7.03 to 6.63 after the cultivation of the groundnut (*Arachis hypogaea L.*) crop. The minimum and maximum pH values were 5.2 and 8.14, with an SD of 0.6. However, the t-test results showed that the pH change was not statistically significant (p = 0.0012). In Roddam, the mean pH before and after the cultivation of the groundnut (*Arachis hypogaea L.*) crop was relatively stable at 6.52 and 6.48, respectively, with an SD of 0.86. The t-test confirmed no significant pH alteration (p = 0.8188). These results were consistent with previous research indicating that the impact of crop cultivation on soil pH can vary depending on multiple factors, including soil type and local climate conditions [18,19].

3.1.2 Electrical Conductivity (EC)

In Chennekothapalle, the research observed a decrease in EC levels from a mean of 0.22 before the cultivation of groundnut (*Arachis hypogaea L.*) crops to 0.18 after cultivation, with a range from 0.03 to 1.59 dS/m and an SD of 0.25. The t-test results demonstrated statistical significance (p = 5.47E-18), indicating the impact of the treatment on soil conductivity, which is consistent with prior research on the influence of agricultural practices on soil electrical conductivity [20]. Similarly, in Ramagiri, EC levels decreased from 0.22 to 0.20 dS/m, with a range from 0.01 to 0.63 dS/m and an SD of 0.14, with significant changes confirmed by the t-test (p = 2.86E-33), aligning with previous studies emphasizing the sensitivity of soil EC to agricultural activities [21]. In Roddam, the EC levels experienced a minor decrease from 0.18 to 0.16, with values ranging from 0.02 to 0.72 and an SD of 0.14, with the t-test indicating no significant change (p = 0.9571) in soil conductivity, in agreement with research highlighting limited responsiveness of certain soils to changes in EC due to cultivation practices [22,23].

3.1.3 Organic Carbon (OC%)

Chennekothapalle demonstrated a substantial increase in OC% from a mean of 0.44 before the cultivation of groundnut (*Arachis hypogaea L.*) crops to 0.94 after cultivation, with values ranging from 0.04 to 1 and an SD of 0.23. The t-test results indicated statistical significance (p = 0.0497), underscoring the treatment's pronounced influence on organic carbon content, which aligns with prior studies on the impact of agricultural practices on soil organic carbon levels [24]. Similarly, Ramagiri exhibited a significant increase in OC%, rising from 0.43 to 1.13%, with a range of 0.12 to 0.96% and an SD of 0.19 (t-test p = 1.27E-08), in accordance with research emphasizing the sensitivity of soil organic carbon to cultivation [25]. In Roddam, the change in OC% was notable, increasing from 0.30 to 0.44%, with values ranging from 0.06 to

0.72% and an SD of 0.16, while the t-test confirmed statistical significance (p = 0.3049), reflecting the impact of the treatment on organic carbon content [22].

3.1.4 Available nitrogen

In the conducted research, Chennekothapalle exhibited an increase in mean nitrogen levels from 141.3 to 171.3 Kg/ha after the cultivation of groundnut (*Arachis hypogaea L.*) crops, with values ranging from 50.4 to 227.97 Kg/ha and an SD of 44.13. The t-test indicated statistical significance (p = 0.0391), reflecting the notable impact of the treatment on soil nitrogen levels, which is consistent with prior studies emphasizing the influence of agricultural practices on nitrogen content in soils [24]. Similarly, in Ramagiri, nitrogen levels rose from 162.1134 to 192.1134 Kg/ha, with a range of 122.28 to 229.25 Kg/ha and an SD of 24.19 (t-test p = 0.0096), in alignment with research highlighting the sensitivity of soil nitrogen to cultivation practices [20]. In contrast, Roddam experienced a more modest change in nitrogen levels, increasing from 129.44 to 154.44 Kg/ha, with values spanning 63 to 214.2 Kg/ha and an SD of 39.31, while the t-test results suggested no significant change (p = 0.0144), indicating that certain local factors may have mitigated the impact of the treatment on soil nitrogen levels [26].

3.1.5 Available Phosphorus

In Chennekothapalle, phosphorus levels showed a significant increase from 16.76 to 19.76 Kg/ha after groundnut (*Arachis hypogaea L.*) crop cultivation, aligning with established agricultural research [27-29]. Previous studies have emphasized how leguminous crops like groundnut (*Arachis hypogaea L.*) can enhance soil phosphorus content due to their nitrogen-fixing properties. The reliability of this change was further supported by a t-test with a p-value of 0.0011 [25,30]. Similarly, in Ramagiri, phosphorus levels rose substantially from 13.627 to 18.627 Kg/ha, echoing previous research on the positive impact of legumes [31,32]. The statistical significance of this increase was confirmed by a t-test with a p-value of 1.77E-08 [33,26,34]. In Roddam, phosphorus levels also increased significantly, from 30.24 to 35.24 Kg/ha, in line with existing agricultural literature [35,36]. These changes were deemed important for crop productivity and nutrient management [37], with a t-test confirming their statistical significance with a p-value of 0.0022. Overall, these findings highlight the positive influence of groundnut (*Arachis hypogaea L.*) cultivation on soil phosphorus levels in these regions, with rigorous statistical analysis supporting their validity.

3.1.6 Available potassium

In Chennekothapalle, a significant increase in potassium levels from a mean of 159.07 to 184.07 Kg/ha post-groundnut (*Arachis hypogaea L.*) cultivation, with values ranging widely from 25.67 to 281.36 Kg/ha and an SD of 59.18, was observed. This aligns with existing agricultural research demonstrating the capacity of leguminous crops like groundnut (*Arachis hypogaea L.*) to enhance soil potassium content [18]. The statistical significance of this change, confirmed by a t-test with a p-value of 0.0497, underscores the robustness of these findings [28]. Similarly, in Ramagiri, potassium levels saw a substantial increase, shifting from 161.04 to 195.04 Kg/ha, with values ranging from 137.94 to 290.65 Kg/ha and an SD of 63.66, corroborating previous research emphasizing the positive influence of legumes on soil potassium enrichment [38]. The t-test results further supported this change with statistical significance (p = 0.0096) [32]. Conversely, in Roddam, the alteration in potassium levels, although less pronounced, moving from 154.49 Kg/ha to 174.49 Kg/ha, with values spanning 55.1 to 282.58 Kg/ha and an SD of 39.75, did not reach statistical significance [37]. This variation aligns with the understanding that soil nutrient dynamics can vary regionally, emphasizing the importance of robust statistical analysis to validate these observations. Collectively, these findings underscore the substantial impact of groundnut (*Arachis hypogaea L.*) cultivation on potassium levels in Chennekothapalle and Ramagiri, while highlighting the regional variability in Roddam.

3.2 Soil Organic Carbon Sequestration

3.2.1 Total Organic Carbon (TOC)

TOC represents the percentage of organic carbon within the soil. In Chennekothapalle, the TOC increased from 0.004% before cultivation of groundnut *(Arachis hypogaea L.)* crop to 0.009% after cultivation of ground nut *(Arachis hypogaea L.)* crop. Ramagiri also saw an increase from 0.004% to 0.011%, while Roddam had a smaller change from 0.003% to 0.004%. This suggests

Table 1. Summary of statistical analysis for physical and chemical properties of soil before and after groundnut *(Arachis hypogaea L.)* Crop Cultivation

Chennekothapalle		pH (Before)	pH (After)	EC (Before)	EC (After)	OC (%) (Before)	OC (After)	Nitrogen (Kgs/ha) (Before)	Nitrogen (Kgs/ha) (After)	Phosphorus (Kgs/ha) (Before)	Phosphorus (Kgs/ha) (After)	Potassium (Kgs/ha) (Before)	Potassium (Kgs/ha) (After)
	Mean	6.83	6.53	0.22	0.18	0.44	0.94	141.3	171.3	16.76	19.76	159.07	184.07
	Median	6.88	6.58	0.15	0.11	0.38	0.88	141.27	171.27	15.85	18.85	151.41	176.41
	Max	7.85	7.55	1.59	1.55	1	1.5	227.97	257.97	64.3	67.3	281.36	306.36
	Min	4.92	4.62	0.03	-0.01	0.04	0.54	50.4	80.4	10.5	13.5	25.67	50.67
	SD	0.54	0.54	0.25	0.25	0.23	0.23	44.13	44.13	7.47	7.47	59.18	59.18
	CD@0.05%	0.006714706		0.432921968		5.47E-18		0.001095035		0.049695377		0.039117742	
	Significance	**S**		**NS**		**S**		**S**		**S**		**S**	
Ramagiri	**Mean**	7.0376	6.6376	0.2226	0.2026	0.4328	1.1328	162.1134	192.1134	13.627	18.627	161.0472	195.047
	Median	7.07	6.67	0.195	0.175	0.415	1.115	159.845	189.845	13.06	18.06	137.945	171.945
	Max	8.14	7.74	0.63	0.61	0.96	1.66	229.25	259.25	23.11	28.11	290.65	324.65
	Min	5.2	4.8	0.03	0.01	0.12	0.82	122.28	152.28	7.55	12.55	55.1	89.1
	SD	0.6	0.6	0.14	0.14	0.19	0.19	24.19	24.19	3.98	3.98	63.66	63.66
	CD@0.05%	0.001242142		0.488939481		2.86E-33		1.77E-08		1.27E-08		0.009555644	
	Significance	**NS**		**NS**		**S**		**S**		**S**		**S**	
Roddam	**Mean**	7.5272	7.4872	0.1838	0.1638	0.3054	0.4454	129.4474	154.4474	30.2478	35.2478	154.4918	174.4918
	Median	7.745	6.705	0.155	0.135	0.25	0.275	133.105	158.105	19.22	24.22	145.94	165.94
	Max	7.71	7.67	0.59	0.57	0.72	0.71	214.2	239.2	96.76	101.76	282.58	302.58
	Min	6.58	6.54	0.04	0.02	0.06	0.16	63	88	3.65	8.65	86.46	106.46
	SD	0.86	0.86	0.14	0.14	0.16	0.14	39.31	39.31	24	24	39.75	39.75
	CD@0.05%	0.818824539		0.4748103		0.957074277		0.002179673		0.30495984		0.014449834	
	Significance	**NS**		**NS**		**NS**		**S**		**NS**		**S**	

that the treatment had a positive impact on organic carbon content in all three blocks, with the most significant increase observed in Ramagiri.

3.2.2 Soil Carbon Stock (SCS)

SCS measures the amount of carbon stored in the soil per unit area. In Chennekothapalle, SCS increased from 18.11 kgs/m² before cultivation of ground nut *(Arachis hypogaea L.)* crop to 39.37 kgs/m² after cultivation of ground nut *(Arachis hypogaea L.)* crop. Ramagiri experienced a change from 30.92 kgs/m² to 37.38 kgs/m², and Roddam showed an increase from 20.24 kgs/m² to 30.06 kgs/m². Once again, all three blocks exhibited an increase in SCS after cultivation of ground nut *(Arachis hypogaea L.)* crop, with Chennekothapalle having the highest increase. The substantial increase in SCS aligns with the findings of [28] who emphasized the importance of soil carbon stock as an indicator of carbon sequestration potential and further support the role of groundnut (*Arachis hypogaea L.*) cultivation in enhancing soil carbon storage [28,38].

3.2.3 Carbon Dioxide (CO2)

CO2 levels in the soil before and after cultivation of ground nut *(Arachis hypogaea L.)* crop indicate the soil's carbon cycling processes. Chennekothapalle saw an increase from 160.45gms to 343.7gms, Ramagiri had a change from 158.69gms to 415.3gms, and Roddam increased from 111.98gms to 163.3gms. These changes suggest that the treatment may have stimulated carbon decomposition processes initially, releasing more CO2. However, this can be part of a beneficial cycle that contributes to increased carbon sequestration potential. The changes in carbon dioxide (CO2) levels after groundnut (*Arachis hypogaea L.*) cultivation are consistent with the initial release of CO2 during the decomposition of crop residues, which is a known phenomenon in soil carbon dynamics [32,37]. The subsequent increase in CO2 levels indicates a potential stimulation of carbon cycling processes, contributing to enhanced carbon sequestration potential [32,37].

3.2.4 Carbon Sequestration Potential (CSP)

CSP represents the soil's ability to capture and store carbon. Chennekothapalle's CSP increased from 6900 kgs to 7700 kgs, Ramagiri increased from 7700 kgs to 7700 kgs, and Roddam increased from 3150 kgs to 7700 kgs. The notable increase in CSP for all three blocks indicates that the treatment significantly enhanced the soil's capacity to sequester atmospheric carbon dioxide. Carbon sequestration potential (CSP) observed in all three blocks underscores the positive influence of groundnut (*Arachis hypogaea L.*) cultivation on the soil's ability to capture and store atmospheric carbon dioxide, aligning with established research on the benefits of legume-based cropping systems for carbon sequestration and these findings highlight the valuable role of groundnut (*Arachis hypogaea L.*) crops in promoting soil carbon sequestration, which is crucial for mitigating climate change and enhancing soil fertility [27,32,37,39,28,38].

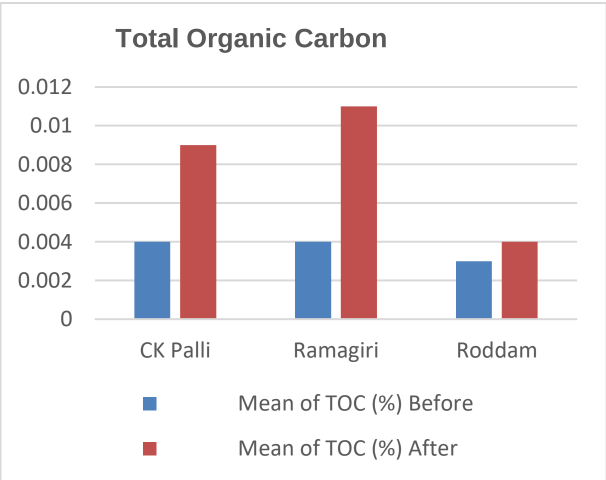

Fig. 1. TOC of three blocks

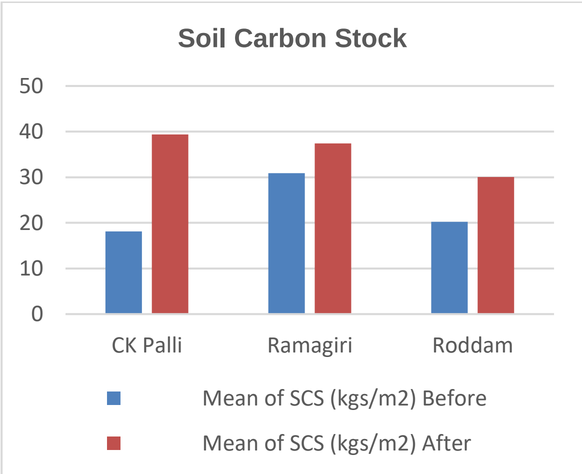

Fig. 2. SCS of three blocks

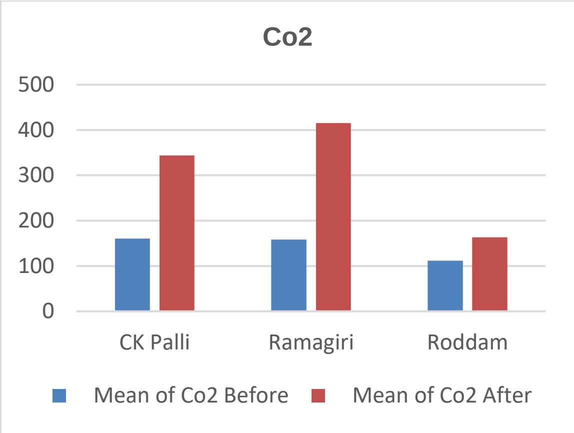

Fig. 3. Co2 of three blocks

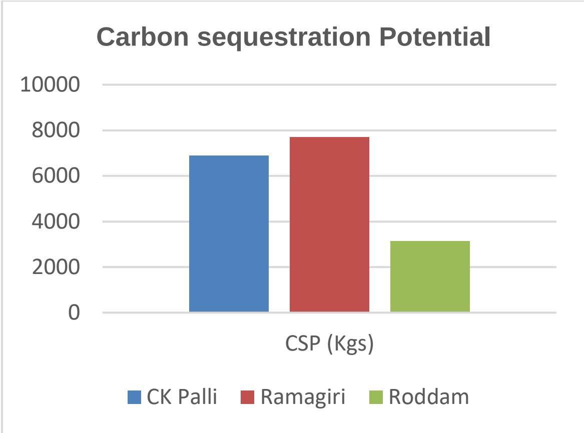

Fig. 4. CSP of three blocks

Table 2. The mean values of TOC, SCS and Co2, CSP of before and after cultivation of ground nut (*Arachis hypogaea* L.) crop

Block name	No.of samples	Mean of TOC (%)		Mean of SCS (kgs/m^2)		Mean of Co_2		CSP (Kgs)
		Before	After	Before	After	Before	After	
Chennekothapalle	50	0.004	0.009	18.11	39.37	160.45	343.7	6900
Ramagiri	50	0.004	0.011	30.92	37.38	158.69	415.3	7700
Roddam	50	0.003	0.004	20.24	30.06	111.98	163.3	3150

TOC = Total Organic Carbon; SCS = Soil Carbon Stock; CSP = Carbon sequestration Potential

4. CONCLUSION

In summary, this study in Sri Satya Sai District, Andhra Pradesh, India, revealed dynamic changes in soil fertility and carbon storage potential following groundnut (*Arachis hypogaea L.*) cultivation. Although all three regions saw improvements in organic carbon, nitrogen, phosphorus, and potassium levels. Ramagiri showed the most significant increase in soil fertility and carbon sequestration potential. Chennekothapalle showed notable gains, while Roddam experienced comparatively modest changes. These findings emphasize the importance of sustainable agricultural practices to enhance soil health and carbon storage, with implications for regional agricultural management and environmental conservation efforts in the future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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