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Enhancing Soil health and climate resilience through sustainable agriculture practices

Vairagar Rushikesh Ramesh[1], G. Surya Prakash Reddy[2], Krishna Nand Mishra[2], Abhipreeti Sheet[2]
Department of Agricultural Biotechnology and Molecular Biology,
Dr. Rajendra Prasad Central Agricultural University
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Abstract

Sustainability in agriculture can be described as the capacity of a crop cultivation system to endlessly produce food while not degrading the environment. This paper is going to be a review incorporating a bibliometric analysis to answer how, practices of sustainable agriculture Improves Climate resilience and Soil health. Healthy soil is intrinsically part of sustainable agriculture since soil microbial activity and community are the major elements of healthy soil.

Introduction:

As elevating change in Climate, to increase of preserve Soil health the Sustainable Agricultural Practices are required that plays Crucial Role For development of Climate-Resilient Agriculture System. This Article focuses major practices for Soil Health Such as Crop Rotation, Cover Cropping, organic amendments, Agroforestry with Nutrient cycling of overall function of ecosystem it also upgrades Resilience to elevating weather events like drought & Floods. Agriculture is modifying by Sustainable Agriculture practices due to Result of improve biodiversity, revive soil well-being also contribution of Climate Resilience. (kabenomuhagi 2024). Sustainable Agriculture is new System of Farming Works towards Increasing biodiversity, Fertility of Soil & renovate environment Through ecological Friendly practices.

Common old practices of Agriculture like as Crop rotation & intercropping, enhance fertility of Soil & is Significant to Climate resilience by Imprinting Species within Farming landscapes (Pretty, 2008). Yet, Automated Agriculture in 20th Century is crucial turning point. massive loss of biodiversity of boss of is Crucial environmental Result as huge use of fertilizers and Pesticides (Foley et al. 2011) Historical Agriculture give priority to short-Term harvesting by using mono-Cropping & implication of Chemical has reduced the Animal and

Crop Gene diversity, up-raising The Susceptibility of Agricultural practices to diseases, pests and extreme weather Conditions (Tilman et al 2002) biodiversity is plays important Role for ecosystem for pollination, Regulation of past and Cycling of Nutrients has been lost at Vast amount, Today The goal of Sustainable Agriculture is Reverse This trend by replacing Special attention on the Significance of biodiversity in Restore Soil and develops Long-Team Agriculture resilience. It promotes diverse species and farming practices that are in sync with nature, creating productive and sustainable ecosystems.

Soil is a four-dimensional natural body situated at the lithosphere-atmosphere boundary that is an organic-carbon-mediated domain where solid, liquid and gaseous phases engage across a variety of scales to produce many ecosystem products and services. Soil organic carbon (SOC) has significant influences on soil functionality, quality, and health. Soil quality and soil health must not be utilized interchangeably. Soil quality is concerned with what it does (functions), while soil health considers soil as a living biological organism that influences plant health. Through plant growth, soil health is also linked to the health of animals, humans, and ecosystems within its jurisdiction. (Rattan Lal, 2016)

Soil health is the pillar of sustainable agriculture that serves as an Energetic ecosystem essential for plant growth, water management, and carbon sequestration. Nevertheless, conventional agricultural methods tend to degrade soil, affecting crop yields and fueling climate change. This review assesses how sustainable agriculture practices can be manipulated to promote soil health, ease climate change effects, and achieve agricultural system resilience (That et. Al., 2020).

Objectives for the Review Article

1. To Define Sustainable Agriculture.
2. To know the Relation between Climate Resilience & Health of Soil
3. Recognize important practices of Sustainable Agriculture
4. Analyze the impact of practices of Sustainable Agriculture on Soil Health

Methodology

Effect on Soil Heath and Resilience of Climate due to Sustainable Agriculture. Pivotal role for elevate Soil health & Supporting Climate Resilience of Sustainable Agriculture Research prove organic Agriculture, Conservation farming, & agroecological management play key role to achieve this target.

Impact on Soil health

The Research Found that Sustainable Agriculture Practices up-raise Soil Health by different ways:

Upgrade Soil structure & Fertility:

Conservation Farming, associated to Decrease Soil disturbance, rotation of Crop & Green manure has associated to up-rasing Soil health by 21% these practices play important role for upgrading soil structure, Organic matter, nutrient cycling for long-time crop productivity. (Mery et al 2024)

Enhanced Soil Diversity:

Methodologies for organic farming that reject Synthetic chemical & boost wide Soil micro-biome that helps to stop Soil-borne infection and move-up soil health by elevating Accessibility of Nutrients (Sharma et al 2024).

Impact on Climate Resilience:

Methods of Sustainable Agriculture also continue Climate Resilience.

Carbon Sequestration:

Cover Cropping & Agroforestry Increase Sequestration of Carbon in Soil which decreases emission of gases of greenhouse and also decrease Capacity of Soil for water holding which is crucial for drought (Kaushika et. al., 2024).

Adaptive Capacity:

Combining agroecological management Substitute, upraise the Volume of Agricultural methods, which brings back degradation of Soil, Minimize the effect of weather change, this is useful for improving resilience of Agriculture for weather Variability. (Davis et. al., 2023)

Common Sustainable Agriculture Practices for Enhancing soil health

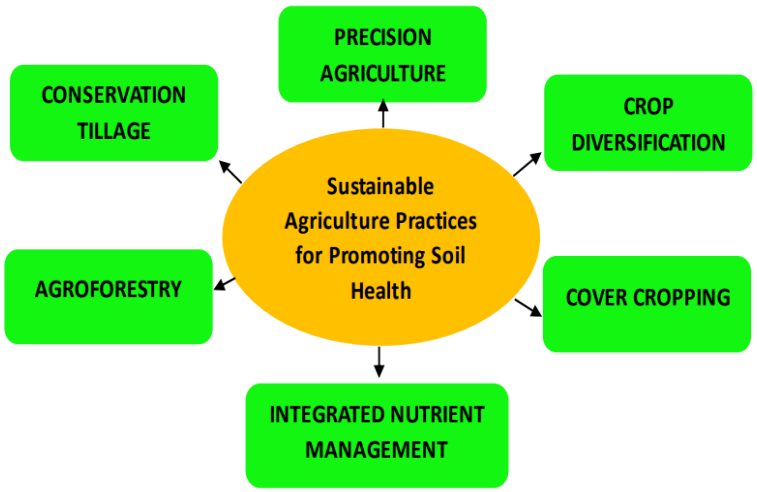

Fig 1: Sustainable agriculture practices for enhancing soil health

1. Crop rotation:

Crop rotation is the common practice of sustainable agriculture in which different variety of Crop is Cultivated in rotational manner in the same farm over time period. It has ability to raise up fertility of Soil by rejecting aggregation of Pest and diseases, increasing nutrient Cycle & Conserving Structure of Soil (Galiu et al 2023) (Indira et al 2023). Research says that diversity or range of planting of Crops on the same farm upgrades soil health by promoting biodiversity, enhance Nutrient cycle and improve overall resilience of ecosystem.

2. Cover Cropping:

In this method the non-harvested Crops planted within main Crop's growing Season for serving variety of ecosystem services like weed Control, Soil erosion, & cycling of Nutrient. This Cover Crops upgrade the Soil health by subsidizing organic matter, up-bringing of Soil structure (Saliu et al 2023).

Conservation Tillage-

Conservation tillage practices are chief leaving from traditional ploughing practices. Taking helpful tillage practice to preserve Soil het Health & plant yields the helpful billage practice is Actopting (Jabra et al 2009). The group of Soil manage management practicalities Conservation bit Tillage it aims to Decrease Sail-craison of Conserve Soil upper layer se quran in of infiltration of Water. (Indira et al. 2023)

4. Organic farming:

Organic farming is a farming method that implement natural processes & materials such as Compost manure. It has been illustrating to raise up of the Soil health by increasing organic matter in Soil, improve nutrients Cycle, formulating biodiversity of Soil. Even few Crops produced by organic farming compares to Conventional farming. (Saliu et. al., 2023)

5. Agroforestry:

Researchers prove that Agroforestry Contain trees of woody perennials in Agriculture System it has ability to improve of quality of Soil by Adding an organic matter into Soil, upgrade nutrient Cycle & diversity of Soil (Saliu et. al., 2023).

6**. Precision agriculture:**

It is a new Cultivation strategy that Apply Sophisticated Technologies Such as Global positioning System (GPS), remote sensing. to level up agricultural Activities and Administrative practices (Saburet. al 2023). By Precisely Adapting such as water, fertilizers, pesticides to the special needs of different parts of farm, Precision Farming bring down wastage and Chemical depurates. This system allows Successful management of Nutrients, avoid applying extra nutrients, that damage soil quality & quality of water also. (Indira et al. 2023)

Common Sustainable Agriculture Practices for Climate Resilience

1. Polyculture farming:

Polyculture Farming is Just like Crop rotation where to natural rules for the sake of maximizing output.

2. Agroforestry:

It is an agriculture system that is useful for farmers who holds arid lands and are endangered to desertification. Under this practice, shrubs and trees are cultivated together with crops or pastures, integrating forestry with agriculture for sustainable, productive, and diverse land use.

3. Better water management:

Planting the appropriate crops based on weather is the first step towards proper water management. The dry areas need to use less water-dependent crops to preserve this valuable resource.

4. Organic farming:

It is the natural process to preserve soil fertility and control pests as alternative to fertilizers and pesticides. This decrease and apply of harmful chemicals in agriculture, stimulate biodiversity, and reduces environmental impression.

5. Conservation tillage:

It is an operation such as zero- till or decrease Tillage, decrease soil disruption and erosion. These activities increase soil structure and also increase moisture retention and allow carbon sequestration. Tractor guru (2022), Snapp& Gentry (2011)

Other uses of sustainable agriculture other than improving soil health and climate resilience

1. Conservation of Biodiversity:

Reestablished practices of farming such as Cover crops and agroforestry, can stimulate biodiversity, these approaches upgrade quality of soil and fertility beside with microbial diversity, which has a dynamic role in nutrient cycling and disease regulation. (Kabenomuhangi et. al., 2024)

2.**Economic Profitability:**

Diversification agricultural practices, such as intercropping and organic agriculture, have been linked to long-term financial profitability. A full examination of 50 years of data showed that diversification is capable of providing significant economic rewards without sacrificing crop yield. (Raveloaritiana et. al., 2024)

3. Technological Innovations:

Growths in plant biotechnology, including CRISPR-mediated genome editing, have been used to improve crop durability and yields. For example, the Innovative Genomics Institute has established methods for editing more than 30 crop species for enhancing traits such as drought resistance and disease immunity. (Doudna et. al., 2015)

4. Food Security:

Sustainable agricultural practices seek to grow farm produce at a low environmental expense while providing food to generations to come. (Sharma et. al., 2024)

Factors affecting Sustainable Farming:

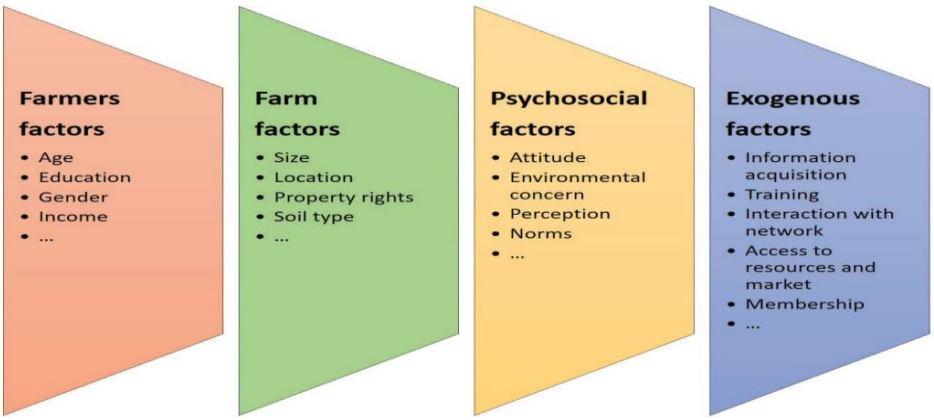

Fig 2: Factors affecting Sustainable Farming

Conclusion:

Sustainable agriculture is significant to stimulate climate resilience and soil health. Through practices like crop rotation, conservation tillage, agroforestry, and precision agriculture, farmers can develop the structure of the soil, enhance organic matter, and enhance biodiversity. These strategies confirm long-term agricultural productivity as well as help in the extenuation of climate change by minimizing greenhouse gas emissions and sequestering carbon.

Healthy soil customs the basis of climate-resilient farming schemes, which helps in improved water retention, nutrient cycling, and erosion control. This improves the capacity of agricultural sites to deal with severe weather conditions like floods, temperature variability, and droughts. Likewise, sustainable agriculture reduces dependence on chemical inputs, reducing environmental pollution but ensuring food security for generations to come.

Even though the benefits are huge, issues like economic policy shortcomings,

limitations, and broadcasting of knowledge restrain large-scale application. Overcoming these problems in the form of supportive policies, economic incentives, and farmer training programs is a requirement for universal adoption of sustainable agriculture worldwide.

Lastly, investing in soil health through sustainable agriculture is a need for keeping productive farmlands as well as a dynamic approach for climate change adaptation and mitigation. Improving research, innovation, and partnership among policymakers, scientists, and farmers will be fundamental to guaranteeing a sustainable and resilient food system in the future.

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