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# SOIL AND ITS CONSTITUTING ELEMENTS FOR PLANT GROWTH: SIGNIFICANT OUTCOMES

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## ABSTRACT

Qualitative research was conducted to explore the bond between soil constituents and plant growth, based on facts and information from archives of botany, environmental studies, ecology, etc. The published data from ICAR and USDA were analyzed as secondary data tools for the objective of this research. The study hypothesized that a concrete analysis of the primary data from both organizations and quality information from published facts on soil and plant nature would help in farming, cultivation, and achieving self-dependency in food, fruits, vegetables, and allied products. The hypothesis was accepted, and its impacts were observed globally, including in India. Analytical results and their rationale could be generalized for better outcomes in agriculture, from farming to commercial plantation and vegetation. This may assist researchers, technocrats, and conscientious farmers as valued stakeholders.

**Keywords:** Soil-Constituents, soil-response, techno-farming, production-alarm.

## 1. INTRODUCTION

The Indian economy is heavily reliant on agriculture. Since gaining independence, the Indian government has prioritized this sector in its national policies, prominently featuring it in the five-year plans. The inaugural Five-Year Plan's focus on agriculture marked a pivotal moment in this journey. The Green Revolution, which commenced in 1960, underscored the integration of modern technology into agricultural practices. Traditional seasonal farming gave way to a more systematic approach, emphasizing quantity and quality in production. Fertilizers and pesticides emerged as indispensable arming tools in enhancing food production. However, the intensification of land use to meet growing demands led to unforeseen challenges, prompting researchers to explore alternative crop cultivation methods. This shift from nature's bounty to artificial methodologies encompasses various aspects, including soil composition and its role in plant growth.

Soil constitutes a vital component of the Earth's ecosystem. An ecosystem, or ecological system, interacts intricately with the environment and organisms (Hatcher, Bruce, & Gordon, 1990). These systems are influenced by both internal and external factors, with climate, parent materials, and topography shaping soil formation. Three primary factors—organic, inorganic, and living organisms, particularly microorganisms—predominate in soil composition, with secondary constituents playing significant roles in classification. Approximately 12% (>12%) of fine-grained and 30% (>30%) of coarse-grained materials comprise these secondary constituents. The life cycle of plants begins with their interaction with soils of varying compositions, influenced by both direct and indirect factors. Studies have revealed that soil is the largest terrestrial carbon sink, harboring approximately 1600 Pg of carbon within a meter's depth

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(Eswaran et al., 1993). Soil organic carbon (SOC) distribution influences biomass precipitation and temperature regulation, affecting factors such as leaching, erosion, and heterotrophic respiration dominated by plant litter. The global review indicates that 1-5% of soil microbial biomass (SOB) contributes to soil organic matter (Sparling, 1992), with environmental changes further influencing it (Kilham, 1994).

Soil and plant interactions are multifaceted, and influenced by numerous factors. Understanding soil contamination classifications—natural (e.g., atmospheric fallout, volcanic eruptions) and artificial (e.g., industrial waste, domestic usage)—is crucial for comprehensive knowledge. Changes in soil composition, water content, and air proportion directly affect plant life. With soil approximately comprising 25% air, 45% minerals, 25% water, and 5% organic matter, cultivation practices must align with these ratios to optimize plant growth. Notably, research by Anwesha Das (2022) on Indian soil samples underscores the importance of organic and inorganic fractions in plantations. Phosphorus (P) emerges as a dynamic factor in plant growth, highlighting the significance of understanding soil and plant dynamics (Chan et al., 2021; Yasmeen et al., 2022; Prasad & Shivay, 2021). These references provide compelling evidence of soil's profound impact on plant growth, highlighting the pivotal role of soil nature in fostering plant life and growth.

**Objective**: The study is to 'explore the constituting elements of soil and its impact on plant growth to achieve productive outcomes'.

**Hypothesis**: Hypothesized that a technical analysis of primary data from national and international organizations, supplemented by archival inputs, will facilitate informed decision-making regarding the relationship between soil and plant growth.

**Methodology**: This study employs a qualitative research technique based on archived research. A thorough review of relevant literature from libraries and data centers was conducted to extract essential facts. Practical wisdom has been applied extensively during data collection, exploration, and assimilation. The collection and analysis of facts would have focused on the given soil profile diagram. Careful planning and management can aid in maintaining soil at a sufficient level for human needs.

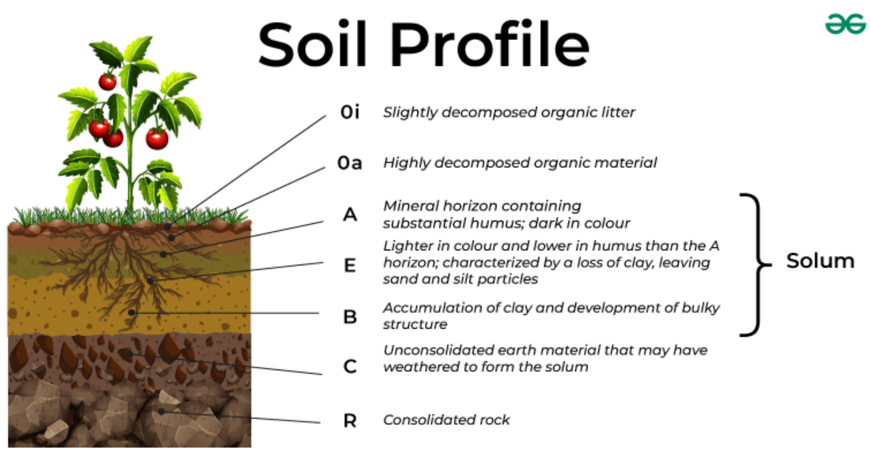


**Figure 1**: Soil and Plants bond [i]

**Data and data analysis**

The Indian Council of Agricultural Research (ICAR) has classified eight types of soil, each responsible for supporting different kinds of plants. These include Alluvial soil, black cotton soil,

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red and yellow soil, laterite soil, mountainous or forest soil, arid or desert soil, saline and alkaline soil, and peaty & marshy soil. Similarly, the United States Department of Agriculture (USDA) characterizes soils based on their nature and characteristics :

**Table 1** : USDA data[ii]

| SN | Order | % |
|---|---|---|
| 1 | Inceptisols | 39.74 |
| 2 | Entisols | 28.08 |
| 3 | Alfisols | 13.55 |
| 4 | Vertisols | 8.52 |
| 5 | Aridisols | 4.28 |
| 6 | Ultisols | 2.51 |
| 7 | Mollisols | 0.40 |
| 8 | Others | 2.92 |

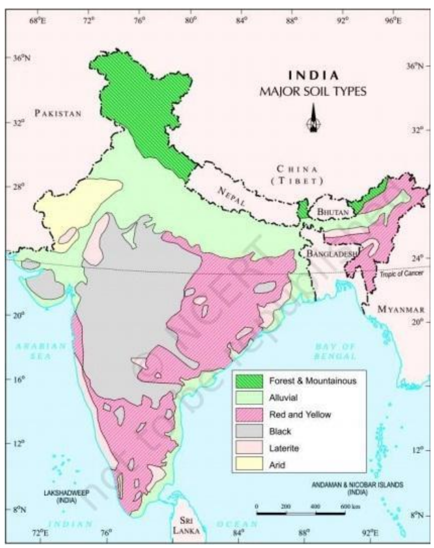


**Figure 2**: Geographical distribution of soils and plant status[iii].

In addition to these classifications, another important aspect for understanding soils and plants is the vertical cross-sectional approach for deeper study. The vertical cross-section profile reveals three layers of texture known as horizons: Topsoil, which contains minerals, nutrients, and water; Subsoil, comprising minerals and humus; and Weathered and decomposed rock, consisting of loose parent or rock materials. It cannot be said that soil directly produces plants; rather, it is the pores of soil that support plant growth. These pores are the spaces between soil particles, classified as Macropores (spaces greater than 0.03mm) and Micropores (spaces less than 0.03mm). The solid-state of soil primarily consists of minerals, constituting approximately 90% of the solid materials, with the remaining portion being organic material. The USDA has conducted a technical classification of three types of soils: sands, silts, and clay, as detailed in Table 2.

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**Table 2. Soil and Particle diameters[iv]**

| Soil Type | Particle diameter (mm) | Surface area for 1 gr ( Sq Cm ) |
|---|---|---|
| Very Coarse sand | 2.0 -1.0 | 11 |
| Coarse sand | 1.0 - 0.5 | 23 |
| Medium sand | 0.5 - 0.25 | 45 |
| Fine sand | 0.25 – 0.10 | 91 |
| Very fine sand | 0.10 – 0.05 | 227 |
| Silt | 0.05 -0.002 | 454 |
| Clay | < 0.002 | 8000000 |

The relationship between soil and plants is a central theme in environmental biology. It is a well-researched and universally acknowledged fact that soil plays a key role in plant growth. Researchers studying the nature of plants and their growth profiles have categorized six types of soils: Loamy soil, Sandy soil, Peaty soil, Silty soil, Chalky soil, and Clay soil. Loamy soil, composed of clay and silt, is ideal for plant growth due to its nutrient-rich composition, moisture retention, and excellent drainage properties. This soil type is conducive to the cultivation of a variety of crops, including vegetables, berries, drought-tolerant crops, and flowers. Sandy soil, characterized by its coarse texture, is prone to water erosion but can be improved with the addition of organic fertilizers and matter. Peaty soil, resulting from the high-level decomposition of organic materials, is suitable for growing vegetables, shrubs, trees, and grass crops. Silty soil is compatible with shrubs, trees, and vegetable crops. Chalky soil, often found in high-altitude areas, has an alkaline nature and lower nutrient content, making it suitable for vegetable crops, trees, and shrubs. Clay soil, with its high water retention capacity, is friendly to fruits, vegetables, shrubs, and perennials. Soil analysis and comparison are facilitated by algorithms such as Naive Bayes, J48 (C4.5), and JRip, which aid in data estimation, classification, and error reduction, providing valuable insights for plant growth studies.

## 2. RESULTS

The following insightful results were obtained from the technical analysis of data :

1. Promotion can be done in regional farming for self-dependency on vegetables, food grains, and fruits through organic cultivation
2. Soil research testing laboratories are required for promotion.
3. Plantation should be a microanalysis of soils and water retention capacity in the soils.
4. Scientific analysis is required for plant sensitivities. It would help to advance development in plantations.

## 3. DISCUSSION

Facts demonstrate the existence of strong bonds between soil and plants. Russell's book 'Lessons on Soil', published in 1912, stands as one of the pioneering works in this field. According to Russell, understanding soil is essential for comprehending flora and fauna. Plants exhibit responses to soil conditions (Davies and Zhang, 1991; Jackson, 1993; Aiken and Smucker, 1996). Analytically, plant responses to soil are explained in control theory as feedforwards, which elucidates direct environmental sensing. In plants, this response is highly conservative, driven by two factors: the restrictive environment and the typical physical range (details provided in the facts and analysis section). The soil's response range for plant growth is classified into three categories: physical (hardness and dryness), chemical (hypoxia and salinity), and biological (initial infection by disease). The nature and quality of soil are directly linked to plant growth. Soil and plant researchers express gratitude to Weil and Brady (2017) for their analytical contributions in the book 'Nature and Properties of Soils (first published in 1913). This serves as a literature guide for studying soil properties and plant behaviours. Insights into humus, soil carbon, and the principles of organic farming foster advancements in modern agricultural technology, including crop production, water conservation, irrigation techniques, soil food web technology, disease management, and soil's interaction with global climate change. Studies have also explored maximization of production while maintaining leaf water in the soil-plant bond (Merrill & Rawlins, 1979; Garside et al., 1992). Biochemistry and internal physiology, in conjunction with soil nature, have been investigated. Soil hardness may affect shoot growth, which can be reviewed in terms of water and nutrient impacts with feedforward responses. Studies on plants growing in hard soil are influenced by water content density, but the luxurious application of phosphorus does not affect leaf water potential (Masle & Passioura, 1987; Masle, 1998). Research on root-soil association has affected plant nature and growth rates, emphasizing the necessity of root, plant, leaf, and seed analysis in studying plant ecology. Agronomic studies can further enhance this knowledge for crop cultivation. This study encourages considering microorganisms that influence direct drilling, including Rhizoctonia root–rot and Pythium.

Modern agro-engineering and its application for quality and quantity production have altered farming practices and motivated researchers to conduct high-quality research on soil nature and plant quality. Such research stimulates seed selection, plantation area determination, and plant technique and technology selection. Plant growth is dependent on soil nature, and deep ecological and agro-environmental studies may enhance the study paradigm and real-life application objectives.

## 4. CONCLUSION AND APPLICATION

This review paper consolidates existing knowledge on soil-plant relationships, providing insights for future research and practical applications. Researchers are trying to provide technical input for future planners, designers, and researchers in the field of technical agro-farming. By acknowledging the contributions of previous scholars and presenting current findings, this paper aims to facilitate informed decision-making in agriculture.

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[i] Archive information

[ii] Archive information

[iii] Archive information

[iv] Archive information