International Journal of Plant & Soil Science

Volume 38, Issue 6, Page 216-227, 2026; Article no.IJPSS.158887
ISSN: 2320-7035

Physio-Chemical Properties, Growth Activities in Ground Nut (*Arachis Hypogaea*) by Individual and Mixed Soils (Red Soil, Black Soil, and Alluvial Soil) from Delta Zone of Tamilnadu, India

Manikandan Murugaiyan [a++], Revathi Sundaravadivel [b++*], J. Suguna [b++] and R. Karthika [c++]

[a] *Department of Biochemistry, VYSYA College, Salem-103, India.*
[b] *Department of Biochemistry, Vivekanandha Arts and Science College, Sankagiri, Salem-303, India.*
[c] *Department of Biochemistry, Theivanai Ammal College for Women (Autonomous), Villupuram – 602, India.*

Authors' contributions

This work was carried out in collaboration among all authors. Author MM designed the study and performed the statistical analysis. Author RS wrote the protocol and prepared the manuscript from the first draft to the final draft. Authors JS and RK managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2026/v38i66112

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/158887

Original Research Article

Received: 11/03/2026
Accepted: 23/05/2026
Published: 01/06/2026

[++] *Assistant Professor;*
**Corresponding author: E-mail: biocemrevathi@gmail.com;*

Cite as: *Murugaiyan, M., Sundaravadivel, R., Suguna, J., & Karthika, R. (2026). Physio-Chemical Properties, Growth Activities in Ground Nut (Arachis Hypogaea) by Individual and Mixed Soils (Red Soil, Black Soil, and Alluvial Soil) from Delta Zone of Tamilnadu, India. International Journal of Plant & Soil Science, 38(6), 216–227. https://doi.org/10.9734/ijpss/2026/v38i66112*

Abstract

Background: Soil physico-chemical characteristics strongly influence plant growth and agricultural productivity, particularly in nutrient-demanding crops such as groundnut (*Arachis hypogaea*). Red, black, and alluvial soils of the Tamil Nadu delta region exhibit distinct fertility profiles, and their mixing may modify nutrient availability and crop performance.

Aim: This study systematically evaluated the effects of individual and mixed soil systems on soil properties and groundnut growth responses.

Methods: A controlled experimental study was conducted using red soil, black soil, and alluvial soil collected from Pudukottai, Coimbatore, and Thanjavur districts of Tamil Nadu, India. Soil samples were analyzed individually and in equal combinations (1:1 and 1:1:1). Physico-chemical parameters including pH, electrical conductivity, texture, water-holding capacity, organic carbon, and macronutrients (N, P, K) were assessed using standard laboratory methods (Walkley–Black, Kjeldahl, Olsen, and flame photometry). Groundnut seeds were grown in each soil type under controlled conditions for 30 days. Growth performance (germination, plant height, leaf and branch number) and biochemical parameters (chlorophyll, moisture, and ash content) were recorded and compared across treatments.

Results: Mixed soil treatments showed improved physico-chemical properties compared to individual soils, with higher organic carbon (0.25–0.64%), nitrogen (50–72.4 kg/ha), phosphorus (7–10 kg/ha), and potassium (85–500 kg/ha). Soil pH remained moderately alkaline (7.9–8.4) across all treatments. Water-holding capacity and nutrient retention were notably higher in mixed soils, particularly in black–alluvial and tri-soil combinations. Enhanced plant growth was observed in mixed soils, with maximum plant height reaching 25 cm and improved leaf and branch formation. The red–black–alluvial (1:1:1) combination recorded the highest chlorophyll content (13.6 µg/100 mg fresh leaf), along with improved moisture and ash content. Germination and plumule development were also faster and more uniform in mixed soil systems.

Conclusion: The blending of red, black, and alluvial soils significantly enhances soil fertility and improves groundnut growth performance. Mixed soil systems optimize nutrient availability, moisture retention, and overall soil quality, making them more suitable for sustainable agricultural and horticultural applications. The study highlights soil blending as an effective strategy for improving crop productivity in deltaic regions of Tamil Nadu.

Keywords: Ground nut; soil analysis; physio-chemical properties; growth activity.

1. Introduction

Agriculture plays a vital role in the world's economy, and crop yield is primarily determined by the nutritional quality of the soil, which serves as the main medium for plant growth and a major component of the terrestrial ecosystem. Soil biodiversity extends from a few meters to more than three meters beneath the Earth's crust and consists of sand, silt, and clay. The upper layers of soil contain organic matter derived from the decomposition of plants, animals, and other biological materials, which contribute to the formation and structure of the soil (Srivastava & Rajwar, 2021; Balasubramanian, 2017; Eyayu et al., 2009; FAO, 2016; Gadani, 2010).

The essential quality components of soil, particularly soil nutrients, play a crucial role in determining agricultural sustainability, productivity, soil management, and the health of both animals and human beings. Soil deterioration, influenced by physical, chemical, and biological characteristics, has significantly contributed to soil degradation. This decline is mainly attributed to severe soil erosion, excessive cultivation, improper fertilizer application, unsuitable land use practices, and other poor soil management strategies. Furthermore, changes in land use and the resulting ecosystem alterations can profoundly affect soil properties (Bizuhoraho et al., 2018; Guzman & Al-Kaisi, 2011; Marschner, 1995; Mengel et al., 2001; Sikora & Stott, 1996).

Soil that provides sufficient nutrients essential for plant growth, along with an appropriate pH level, can produce higher-quality crops and greater yields, provided that other growth conditions, including the physical and biological properties of the soil, are also favorable. However, soil quality is not determined solely by its ability to supply adequate nutrients; it is equally important that these nutrients are available in the correct proportions required by plants (Ayeni & Adeleye, 2011; Natural Resources Conservation Service, 2022).

The analysis of soil, including both physical and chemical assessments, is conducted to determine the soil's capacity to supply nutrients to plants in readily available forms and to identify the factors influencing this capability. Nutrient management based on soil testing has become a crucial factor in enhancing agricultural productivity and crop yield. By applying nutrients according to soil analysis results, crop production can be significantly improved while minimizing nutrient wastage. This approach not only increases production efficiency but also reduces the environmental impacts associated with excessive nutrient application (Karande et al., 2020).

Mixed soils can influence plant growth in both beneficial and detrimental ways. In some cases, plant growth in mixed soils has been observed to be slightly lower than expected, suggesting negative interactions among different soil types. Conversely, certain studies have shown that plants grown in mixed soils exhibited fewer disease symptoms than anticipated, indicating positive interactions. The effect of mixed soils on plant growth depends on the specific soil composition and the plant species involved.

The current study focuses on the estimation of soil nutrients and the evaluation of physical and chemical parameters using soil samples collected from the field and analyzed in the laboratory. The main objective of the present study was to evaluate the physical and chemical properties of selected soils from the delta region of Tamil Nadu. The specific objectives were to determine the physical properties of some selected soils (black, alluvial and red soil) and its combination, Identify the chemical properties of some selected soils (black, alluvial and red soil) and its combination, Estimation of macro nutrients such as organic carbon, nitrogen, Phosphorous and potash in the above selected soil and its mixed ratios, Determination of growth activity in ground nut (*Arachis hypogaea*) in mixed soil, Estimation of Chlorophyll, moisture and ash content in whole plant of ground nut (*Arachis hypogaea*).

2. Materials and Methods

2.1 Collection and Preparation of Soil Samples

The soils collected from the study area were analyzed for their chemical and physical properties, as well as for their effect on the growth activities of groundnut plants in mixed soil combinations prepared in equal proportions.

The soil samples, namely red soil, black soil, and alluvial soil, were collected from three different regions of Tamil Nadu, India, namely Pudukottai, Coimbatore, and Thanjavur, respectively. Three soil samples were randomly collected from each location by digging up to a depth of 20 cm. Approximately 5 kg of soil was collected from each site. From each soil type, three subsamples of 1 kg each were thoroughly mixed in a large container, and a final composite sample of approximately 3 kg was prepared for laboratory analysis.

In addition to the individual soil samples, mixed soil combinations such as red-black soil, black-alluvial soil, red-alluvial soil, and red-black-alluvial soil were prepared in equal proportions (1 kg each) for laboratory testing.

About 5 g of each individual and mixed soil sample was taken and subjected to various physical and chemical analyses. The individual and mixed soil samples were also prepared for seed germination studies. For this purpose, the soils were moistened with water and maintained for 60 hours. After the preparation period, 50 groundnut seeds were sown in each soil sample. Germination percentage and the physical growth parameters of groundnut seedlings were then analyzed over an experimental period of 30 days.

2.2 Soil Analysis

Particle size distribution was determined using the hydrometer method (Gee & Bauder, 1979), while soil texture was identified by the feel method. Soil pH was measured in a 1:2 (w/v) soil-water suspension using a pH meter equipped with a glass electrode (Black, 1965). Electrical conductivity was determined by the conductivity method. Organic carbon content was estimated using the modified Walkley–Black method (Walkley & Black, 1934). Phosphorus content was determined by the Olsen method (Olsen et al., 1954), potassium was estimated using the flame photometric method (Toth & Prince, 1949), and nitrogen content was analyzed by the wet digestion method (Kjeldahl, 1883).

2.3 Collection of Seeds

Arachis hypogaea (Ground nut) seeds were collected from the Agricultural College, Annamalai University Chidambaram, Cuddalore district, Tamilnadu, India.

2.4 Chlorophyll, Moisture, and Ash Content Analysis of Ground Nut

2.4.1 Chlorophyll was Estimated by Arnons Method (Arnon, 1949)

The amount of chlorophyll was calculated.

Chlorophyll concentration can be calculated using this formula: Chl. Cone in µg/ml (OD645×20.2)-(OD663×8) this value is then multiplied by 2 to obtain chlorophyll cone per cm^2.

2.4.2 Moisture was Determined by RWC Method (Barr & Weatherley, 1962)

In the laboratory, the vials containing the leaf samples were initially weighed to determine the fresh weight of the samples (W). The samples were then immediately hydrated to attain full turgidity for 4 hours under normal room temperature and light conditions. In some cases, hydration was carried out on the lower shelf of a laboratory refrigerator maintained at approximately 10°C. Samples 1 and 2 were rehydrated by floating them on deionized water in a closed Petri dish, whereas Sample 3 was hydrated by adding water to the vial up to a level of 1–2 cm, after which the vial was tightly capped.

After 4 hours, the samples were removed from the water, and excess surface moisture was gently removed using filter paper. The samples were then immediately weighed to obtain the fully turgid weight (TW). Subsequently, the samples were oven-dried at 80°C for 24 hours and weighed again after cooling in a desiccator to determine the dry weight (DW). All measurements were recorded to the nearest milligram (mg).

2.4.3 Ash Content and Preparation of Solution

Cleaned and pre-weighed silica crucibles were taken, and 1 g of dried leaf powder was accurately weighed into each crucible. The samples were then incinerated at approximately 600°C for 4–6 hours. After cooling, a drop of concentrated nitric acid was added to the ash, and the samples were reheated for 1 hour at the same temperature. The crucibles were then cooled in a desiccator and weighed. The processes of heating, cooling, and weighing were repeated until a constant weight was obtained. The ash content was then determined (Park, 1996).

The obtained ash was dissolved in 1 N HCl and filtered to remove any undissolved matter. The filtrate was then made up to a final volume of 100 mL. This solution was subsequently used for the estimation of calcium, phosphorus, iron, and nitrogen.

2.4.5 Analysis of Growth Activity of Ground Nut in Individual and Mixed Soils

The height, number of leaves and branches were recorded at to 10 days in of total experimental period (30 days). Plumule formation was also recorded in the time 5 days of experimental period. The height of plant was measured by scale (cm) and number of leaves and branches were counted during the experimental period.

3. Results and Discussion

3.1 Physical Properties

Soil test-based fertility management is an effective approach for enhancing the productivity of agricultural soils that exhibit a high degree of spatial variability due to the combined effects of physical, chemical, and biological processes (Goovaerts, 1998).

The electrical conductivity of the soils ranged from 0.09 to 1.0 dS m^{-1}, with an average value of 0.48 dS m^{-1}. The normal electrical conductivity observed in the soils may be attributed to the leaching of soluble salts into the lower soil horizons Table 1.

Table 1. Physical properties of different types of soil

		Soil Properties					
Nature of soil	**Grouping**	**Soil reaction (pH)**	**Soil salinity (E.C) (dSm-1)**	**Soil colour**	**Soil texture**	**Calcareousness**	**Water holding capacity**
Red soil	Group 1	8.2	0.09	Red	Clay-loam	Yes	Low
Black soil	Group 2	8.0	0.44	Black	Clay	No	Normal
Alluvial soil	Group 3	7.9	1.06	Brown	Sandy-Clay	No	High
Red soil + Black soil (1:1)	Group 4	8.2	0.46	Red	Loam	Yes	Normal
Red soil + Alluvial soil (1:1)	Group 5	8.2	0.40	Red	Clay-Loam	Yes	Normal
Black soil + Alluvial soil (1:1)	Group 6	8.3	0.59	Grey	Clay	Yes	High
Red soil + Black soil + Alluvial soil (1:1:1)	Group 7	8.4	0.47	Red	Sandy-Clay	Yes	High

3.1.1 Soil Texture

Soil texture in mixed soils is determined by particle size distribution. In the present study, the texture was modified due to the mixing of individual soil types, which also resulted in variations in soil color. The corresponding data are presented in Table 1. These mixed soil combinations may help improve the water-holding capacity of the soil. In general, variations in soil texture reflect the influence of different land use and land cover patterns on soil properties, which are affected by distinct utilization and management practices associated with various land use systems (Negasa et al., 2017). Practices such as intensive grazing, agriculture, and deforestation contribute to changes in soil texture mainly through increased soil erosion. Factors including watershed area, topographical variations, parent material, land use patterns, and soil management practices significantly influence the proportions of sand, silt, and clay under different land use and land cover conditions (Lemenih, 2004).

3.1.2 Soil pH

Enzymes play a crucial role in nutrient transformation within the soil. However, under conditions of excessively high or low pH, enzyme activity involved in nutrient conversion and humus formation becomes less effective. Soil enzyme activities are strongly influenced by soil pH, which regulates the relationship between soil pH and enzyme activity and thereby affects soil organic carbon (SOC) content (Bueis et al., 2018). It has also been reported that the availability and balance of soil nutrients are greatly influenced by soil pH. Furthermore, the phytotoxic effects of aluminate have been documented in alkaline soils (Kinyangi, 2007). The relatively high pH observed in soils from forest or shrub lands may be due to the greater accumulation of organic matter on the soil surface. It is also believed that soil pH increases with a decrease in the elevation of the watershed area (Kidanemariam et al., 2012).

The data presented in Table 1 show that soil pH ranged from 7.9 to 8.4, with an average value of 8.1. All seven groups of soil samples were found to be moderately alkaline in nature (pH 7.9–8.4). The minimum pH value (7.9) was observed in the alluvial soil sample, whereas the maximum pH value (8.4) was recorded in the mixed soil sample. The variation in pH may be attributed to the interaction of different soil types mixed in equal proportions, as each soil possesses distinct chemical properties. These chemical interactions influence the soil pH through the reaction of basic cations present in the exchangeable complex of the soil.

3.1.3 Water Holding Capacity

Water-holding capacity is primarily determined by the ability of soil to retain water against gravitational force and is closely associated with soil structure and growth conditions. Higher water-holding capacity is generally related to increased organic matter content, larger soil aggregates, and improved moisture retention in traditional agroecosystems (Terashima & Mihara, 2022). The results of the present study showed that Groups 3, 7, and 8 exhibited the highest water-holding capacity when compared to the other groups.

3.1.4 Soil Salinity

Saline soil mainly consist soluble salts like chloride and sulphates of calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate, carbonate are present. Less soluble salts like calcium carbonate and calcium sulphate also present. Dispersion and flocculation also based on clay content of the soil (Ayub, *et al.,* 2020).

3.1.5 Soil Colour

Soil colour reflects the nature and composition of its constituents and is approximately proportional to the total surface area of the soil particles, which is related to the specific surface area and volume percentage. Colloidal materials such as iron oxides and humus exert a major influence on soil colour. According to the soil colour chart, the degree of soil productivity generally follows the order: black > brown > rust brown > gray brown > red > gray > yellow > white (NRCS, 2022).

Based on the observation chart, Groups 2 and 3 exhibited higher soil productivity due to the presence of colloidal materials contributing to greater mineral content. Groups 4–7 showed moderate soil productivity, with the red coloration mainly resulting from the dominance of iron-rich compounds. In contrast, the gray hue observed in Group 6 may indicate wetter soil conditions and lithochromic characteristics.

3.1.6 Calcareousness

The presence of calcium carbonate ($CaCO_3$) in the parent material and the accumulation of lime are characteristic features of calcareous soils. Water availability is considered one of the major limiting factors affecting the productivity of calcareous soils. However, these soils can become highly productive when supplied with adequate water and nutrients. In arid and semi-arid regions, secondary calcium carbonates are formed when the carbonate concentration in the soil solution remains high.

In the present study, calcareousness ($CaCO_3$) was observed in mixed soil combinations such as red soil + black soil, red soil + alluvial soil, black soil + alluvial soil, and red soil + black soil + alluvial soil. In contrast, calcareousness was not observed in the individual black soil and alluvial soil samples, which may favor better plant growth.Calcareous soils generally possess a high buffering capacity, meaning they strongly resist changes in pH. This property is due to the presence of free carbonates, which effectively neutralize acids in the soil. As a result, the pH of calcareous soils remains relatively stable and is usually maintained around pH 8. Owing to this strong buffering nature, lowering the pH of calcareous soils through acidifying amendments is often difficult and expensive.

3.2 Chemical Properties

3.2.1 Organic Carbon

Soil organic carbon (SOC) is an essential indicator of soil health and represents one of the most dynamic components of soil. The amount of SOC processed by soil microorganisms is approximately equal to the quantity of organic inputs derived from plant detritus. The quality and quantity of SOC are closely associated with important soil functions such as trafficability, aeration, water retention, flood regulation, and mineral nutrient availability (Schoenholtz et al., 2000).

In the present study, the organic carbon content of the mixed soils ranged from 0.30% to 0.64%, with an average value of 0.42%. The maximum organic carbon content (0.64%) was observed in the mixed soil combination of red soil, black soil, and alluvial soil. Lower organic carbon content in certain soils may be attributed to higher temperature and increased aeration, which accelerate the oxidation of organic matter. The corresponding data are presented in Table 2. Nitrogen, phosphorus, and potassium are the primary and essential nutrients required for plant growth. These nutrients are generally added to the soil during sowing or through intercultural operations (Fageria, 2005; 2007; Fageria & Baligar, 2005).

Nitrogen is considered the most important mineral nutrient for plants and constitutes approximately 2–5% of the dry weight of plant tissues. It forms a major component of proteins and enzymes involved in energy metabolism. The availability of nitrogen significantly influences plant growth and improves plant quality by increasing protein content (Rajasekar et al., 2017). Since most soil nitrogen occurs in organic form, higher levels of organic nitrogen were observed in the mixed soil samples. The increased nitrogen content may promote better plant growth and nitrogen fixation. The maximum nitrogen content (72.4 kg ha^{-1}) was recorded in the mixed red and black soil combination (1:1). The corresponding data are presented in Table 2.

Table 2. Analysis of macronutrients presence in different types of soils

		Macronutrients			
Nature of soil	**Grouping**	**Organic carbon %**	**Nitrogen (N) (Kg/hec)**	**Phosphorus (P) (Kg/hec)**	**Potash (K) (Kg/hec)**
Red soil	Group 1	0.30	53.4	10.0	50
Black soil	Group 2	0.50	66.0	9.0	165
Alluvial soil	Group 3	0.37	56.4	10.0	500
Red soil + Black soil (1:1)	Group 4	0.48	62.3	7.0	85
Red soil + Alluvial soil (1:1)	Group 5	0.64	72.4	7.0	170
Black soil + Alluvial soil (1:1)	Group 6	0.25	50.0	10.0	140
Red soil + Black soil + Alluvial soil (1:1:1)	Group 7	0.45	62.3	9.0	125

Approximately 30–65% of phosphorus in soil is present in the form of organic phosphorus, which is not readily available to plants, while the remaining portion exists in inorganic forms. The transformation of phosphorus from organic to inorganic forms is mainly mediated by soil microorganisms. Soil parameters such as organic matter content, pH, moisture, and texture are responsible for fluctuations in the availability of phosphorus to plants. In addition, plant-related factors including plant species, age, and root exudates also influence phosphorus uptake by plants (Rassaei, 2023).

The available phosphorus content in the mixed soils ranged from 7 to 10 kg ha^{-1}, with a mean value of 8.8 kg ha^{-1}. This finding indicates that the presence of organic matter enhances the availability of phosphorus in soil. According to Tisdale et al. (1997), nearly 50% of soil phosphorus exists in organic form, and the decomposition of organic matter produces humus, which forms complexes with aluminum (Al) and iron (Fe), thereby reducing phosphorus fixation. Available phosphorus showed a significant positive correlation in mixed soils when compared with individual soil types. The corresponding data are presented in Table 2. Potassium is considered a major constituent of the Earth's crust, with most of its compounds occurring in igneous rocks rather than sedimentary rocks (Kaiser, 1982; Hu et al., 2016). In plants, potassium plays a vital role in metabolic processes and grain or seed yield formation. It also improves the quality of agricultural products, prevents lodging in cereal crops, and imparts resistance against pests and diseases (Mandloi et al., 2022).

The potassium content in the mixed soils ranged from 80 to 170 kg ha^{-1}, with an average value of 176.4 kg ha^{-1}. According to Muhr et al. (1965), most of the soil samples (96%) fell within the medium potassium range (125–300 kg ha^{-1}). This may be due to the creation of a favorable soil environment associated with the presence of organic matter. A significant positive correlation was also observed between available potassium and clay content, possibly due to the occurrence of mica minerals in the finer soil fractions. The maximum potassium content was observed in the mixed red and alluvial soil combination (1:1) as well as in the individual alluvial soil sample. Data presented in the Table-2. Each soils has different physical and chemical properties that the results given by MS Swaminathan Research foundation Taramani, Chennai- 600 113.

3.3 Growth Activity of Ground Nut in Different Mixed Soils

The growth activity of groundnut plants was evaluated using mixed soil samples, and plant growth was monitored over a period of 30 days. During the experimental period, plant height was measured using a scale. Variations in the height of groundnut plants were observed among the mixed soil samples and compared with the individual soil types, namely red soil, black soil, and alluvial soil. The chemical properties of the mixed soils may have contributed to the enhanced growth of groundnut plants, as evidenced by the increased number of leaves and branches observed in each plant. Generally, groundnut cultivation requires a soil depth of approximately 12 cm for optimal growth. However, in the present study, the mixed soils were maintained at a depth of only 5 cm for the experiment. Despite this limited soil depth, the study revealed substantial plant growth, with groundnut plants attaining a maximum height of 17.3 cm. (Data presented in Tables 3 and 4).

Table 3. Growth activity of ground nut in different types of soil

Nature of soil	Height of plant(cm)			Number of leaves			Number of branches		
	10 days	20 days	30 days	10 days	20 days	30 days	10 days	20 days	30 days
Red soil	7.5	16	22	16	24	24	4	6	6
Black soil	8.5	14	25	16	24	24	4	6	6
Alluvial soil	5	18	24	14	24	24	4	6	6
Red soil + black soil	6.5	17.5	21.5	16	24	24	4	6	6
Red soil + alluvial soil	4	20	20	14	24	24	3	6	6
Black soil + alluvial soil	4.5	15	20	12	24	24	3	6	6
Red soil +black soil +alluvial soils	8	20	25	4	24	24	6	6	6

Table 4. Formation of plumule from sowed seeds in different types of soil

Nature of soils	Plumule formation from sowed seeds				
	Day 1	Day 2	Day 3	Day 4	Day 5
Red soil	0	0	1	1	2
Black soil	0	0	1	1	2
Alluvial soil	0	0	0	1	1
Red soil + Black soil	0	1	1	2	2
Red soil + Alluvial soil	0	0	1	2	2
Black soil + Alluvial soil	0	0	1	1	2

0 - No plumule formation
1 - Plumule formation
2 - Leaves, stem, and branches formation from plumule

3.4 Chlorophyll, Moisture and Ash Content in Ground Nut in Growth Activity

Chlorophyll is an essential pigment involved in photosynthesis, enabling plants to capture and convert light energy into chemical energy. Ash refers to the inorganic residue remaining after the removal of water and organic matter through heating in the presence of oxidizing agents, and it serves as an indicator of the total mineral content of a sample. Analytical methods used for determining mineral content are based on the ability to separate and quantify mineral constituents from other components present in the sample.Moisture regulation is an important factor influencing the quality and stability of various products. Even substances that appear dry may contain considerable amounts of moisture. Moisture content can greatly affect the final quality, storage stability, and shelf life of products ranging from cereal-based foods to industrial materials such as detergents.

Table 5. Chlorophyll, moisture and ash content analysis of ground nut leaf

Ground nut growth in types of mixed soils	Chlorophyll content (µg/100 mg of fresh leaf)	Moisture Content (%)	Ash content (%)
Red soil + Black soil (1:1)	9.5	7.5	9.2
Red soil + alluvial soil (1:1)	6.6	7.2	8.2
Black soil + Alluvial soil (1:1)	10.5	8.4	9.2
Red soil + Black soil + Alluvial soil (1:1:1)	13.6	8.7	9.8

Chl. Conc in µg / ml = $(OD645\times 20.2) + (OD663\times 8) \times 2$ (Arnon, D.L.1949)

Data presented in Table 5

The development and composition of the soil system, reflecting the transitional climatic features of the Moole Hole watershed in South India, can be directly evaluated through field surveys and laboratory analyses. In the United States, soil mixing is considered a relatively recent technology for stabilizing loose or soft soils (Al-Tabbaa et al., 2012). Soil mixing techniques have been effectively applied in the construction of steel-reinforced retaining walls and in the mitigation of soil liquefaction. Since many soil properties are interrelated with one another, it is difficult to draw distinct lines of division where one type of property dominates the behavior of the soil. Therefore, understanding and recognizing soil properties and their connections with one another is important for making sound decisions regarding soil use and management.

4. Summary and Conclusion

The proportion of mixed soils comprising red soil, black soil, and alluvial soil, along with their physical, chemical, and biological properties, may significantly influence the growth activity of groundnut plants. The results of the present study indicate that this mixed soil combination is more suitable for agricultural and horticultural practices when compared with individual soil types and other mixed soil combinations.Soil texture, structure, and porosity play important roles in the movement and retention of water, air, and solutes within the soil, thereby promoting plant growth and microbial activity. Most soil chemical properties are associated with the colloidal fraction, which enhances nutrient availability and creates favorable conditions for soil biota. In addition, soil physical properties also contribute significantly to plant growth and soil fertility.

The present study suggests that this mixed soil combination is not only suitable for groundnut cultivation but may also be effectively used for other agricultural practices, the cultivation of flowering plants, the development of grass beds, and various horticultural applications. This suitability may be attributed to the beneficial chemical interactions and nutrient combinations present in the mixed soils, which improve overall soil fertility. The findings of the study revealed that plant growth was better in mixed soils than in individual soil types.

Therefore, the present study concludes that the mixed soil combination of red soil, black soil, and alluvial soil is highly useful for agricultural purposes, particularly in horticulture. This cultivation approach may contribute significantly to advancements in agricultural and horticultural practices.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Al-Tabbaa, A., Liska, M., Ouellet-Plamondon, C., Jegandan, S., Shrestha, R., Barker, P., McGall, R., & Critchlow, C. (2012). Soil mix technology for integrated remediation and ground improvement: From laboratory work to field trials. *Grouting and Deep Mixing 2012*, 522–532. https://doi.org/10.1061/9780784412350.0038

Arnon, D. I. (1949). Copper enzymes in isolated chloroplasts. Polyphenoloxidase in *Beta vulgaris*. *Plant Physiology, 24*(1), 1–15. https://doi.org/10.1104/pp.24.1.1

Ayeni, L. S., & Adeleye, E. O. (2011). Soil nutrient status and nutrient interactions as influenced by agro wastes and mineral fertilizer in an incubation study in the South West Nigeria. *International Journal of Soil Science, 6*(1), 60–68. https://doi.org/10.3923/ijss.2011.60.68

Ayub, M. A., Ahmad, H. R., Ali, M., Rizwan, M., Ali, S., Rehman, M. Z., & Waris, A. A. (2020). Salinity and its tolerance strategies in plants. In D. K. Tripathi, V. P. Singh, D. K. Chauhan, S. Sharma, S. Sahi, & N. K. Dubey (Eds.), *Plant life under changing environment: Responses and management* (pp. 47–76). Academic Press. https://doi.org/10.1016/B978-0-12-818204-8.00003-5

Balasubramanian, A. (2017). *Soil erosion—Causes and effects*. University of Mysore. https://doi.org/10.13140/RG.2.2.26247.39841

Barrs, H. D., & Weatherley, P. E. (1962). A re-examination of the relative turgidity technique for estimating water deficits in leaves. *Australian Journal of Biological Sciences, 15*(3), 413–428. https://doi.org/10.1071/BI9620413

Bizuhoraho, T., Kayiranga, A., Manirakiza, N., & Mourad, K. A. (2018). The effect of land use systems on soil properties: A case study from Rwanda. *Sustainable Agriculture Research, 7*(2), 30–40. https://doi.org/10.5539/sar.v7n2p30

Black, C. A. (Ed.). (1965). *Methods of soil analysis: Part 1. Physical and mineralogical properties, including statistics of measurement and sampling*. American Society of Agronomy. https://doi.org/10.2134/agronmonogr9.1

Bueis, T., Turrión, M. B., Bravo, F., Pando, V., & Muscolo, A. (2018). Factors determining enzyme activities in soils under *Pinus halepensis* and *Pinus sylvestris* plantations in Spain: A basis for establishing sustainable forest management strategies. *Annals of Forest Science, 75*(1), 34. https://doi.org/10.1007/s13595-018-0720-z

Bueis, T., Turrión, M. B., Bravo, F., Pando, V., & Muscolo, A. (2018). Factors determining enzyme activities in soils under *Pinus halepensis* and *Pinus sylvestris* plantations in Spain: A basis for establishing sustainable forest management strategies. *Annals of Forest Science, 75*(1), 34. https://doi.org/10.1007/s13595-018-0720-z

Eyayu, M., Heluf, G., Tekalign, M., & Mohammed, A. (2009). Effects of land use change on selected soil properties in the Tara Gedam Catchment and adjacent agro-ecosystems, northwest Ethiopia. *Ethiopian Journal of Natural Resources*. https://www.ajol.info/index.php/ejnr

Fageria, N. K. (2005). Soil fertility and plant nutrition research under controlled conditions: Basic principles and methodology. *Journal of Plant Nutrition, 28*(11), 1975–1999. https://doi.org/10.1080/01904160500311037

Fageria, N. K. (2007). Soil fertility and plant nutrition research under field conditions: Basic principles and methodology. *Journal of Plant Nutrition, 30*(2), 203–223. https://doi.org/10.1080/01904160601117887

Fageria, N. K., & Baligar, V. C. (2005). Nutrient availability. In D. Hillel (Ed.), *Encyclopedia of soils in the environment* (pp. 63–71). Elsevier. https://doi.org/10.1016/B0-12-348530-4/00236-8

Food and Agriculture Organization of the United Nations. (2016). *Management of calcareous soils*. FAO Soils Portal. https://www.fao.org/soils-portal/soil-management/management-of-some-problem-soils/calcareous-soils/en/

Gadani, D. H. (2010). *Dielectric properties of soils in microwave region* [Doctoral dissertation, Gujarat University]. http://hdl.handle.net/10603/3872

Gee, G. W., & Bauder, J. W. (1979). Particle size analysis by hydrometer: A simplified method for routine textural analysis and a sensitivity test of measurement parameters. *Soil Science Society of America Journal, 43*(5), 1004–1007. https://doi.org/10.2136/sssaj1979.03615995004300050038x

Goovaerts, P. (1998). Geostatistical tools for characterizing the spatial variability of microbiological and physico-chemical soil properties. *Biology and Fertility of Soils, 27*(4), 315–334. https://doi.org/10.1007/s003740050439

Guzman, J. G., & Al-Kaisi, M. M. (2011). Landscape position effect on selected soil physical properties of reconstructed prairies in southcentral Iowa. *Journal of Soil and Water Conservation, 66*(3), 183–191. https://doi.org/10.2489/jswc.66.3.183

Hu, W., Jiang, N., Yang, J., Meng, Y., Wang, Y., Chen, B., Zhao, W., Oosterhuis, D. M., & Zhou, Z. (2016). Potassium (K) supply affects K accumulation and photosynthetic physiology in two cotton (*Gossypium hirsutum* L.) cultivars with different K sensitivities. *Field Crops Research, 196*, 51–63. https://doi.org/10.1016/j.fcr.2016.06.005

Kaiser, W. M. (1982). Correlation between changes in photosynthetic activity and changes in total protoplast volume in leaf tissue from hygro-, meso- and xerophytes under osmotic stress. *Planta, 154*(6), 538–545. https://doi.org/10.1007/BF00402997

Karande, S., Gamit, S., & Prajapati, D. (2020). Analysis of soil samples for its physical and chemical parameters from Mehsana and Patan District. *International Research Journal of Science and Engineering*, Special Issue A9, 86–94. https://irjse.in/ICETCL_2020/IRJSE_SPIA9_18.pdf

Kidanemariam, A., Gebrekidan, H., Mamo, T., & Kibret, K. (2012). Impact of altitude and land use type on some physical and chemical properties of acidic soils in Tsegede Highlands, Northern Ethiopia. *Open Journal of Soil Science, 2*(3), 223–233. https://doi.org/10.4236/ojss.2012.23027

Kinyangi, J. (2007). *Soil health and soil quality: A review*. Cornell University. https://ecommons.cornell.edu/handle/1813/66582

Kjeldahl, J. (1883). Neue Methode zur Bestimmung des Stickstoffs in organischen Körpern. *Zeitschrift für analytische Chemie*. https://doi.org/10.1007/BF01338151

Lemenih, M. (2004). *Effects of land use changes on soil quality and native flora degradation and restoration in the highlands of Ethiopia: Implications for sustainable land management* [Doctoral thesis, Swedish University of Agricultural Sciences]. https://pub.epsilon.slu.se/564/

Mandloi, S., Singh, S., & Prajapati, S. (2022). Potassium and its forms in soil. *The Agriculture Magazine, 1*(4), 10–13. https://theagricultureonline.com/volume-01-issue-04-march-2022/

Marschner, H. (1995). Functions of mineral nutrients: Micronutrients. In *Mineral nutrition of higher plants* (2nd ed., pp. 313–404). Academic Press. https://doi.org/10.1016/B978-0-12-473542-2.50012-5

Mengel, K., Kirkby, E. A., Kosegarten, H., & Appel, T. (2001). *Principles of plant nutrition*. Kluwer Academic Publishers. https://doi.org/10.1007/978-94-010-1009-2

Muhr, G. R., Datta, N. P., Dever, F., & Laley, V. K. (1965). *Test available for N.P.K analysis in different soils*. US Agency for International Development, New Delhi.

Natural Resources Conservation Service. (2022). *The color of soil*. U.S. Department of Agriculture. https://www.nrcs.usda.gov/sites/default/files/2022-11/color-of-soil.pdf

Negasa, T., Ketema, H., Legesse, A., Sisay, M. T., & Temesgen, H. (2017). Variation in soil properties under different land use types managed by smallholder farmers along the toposequence in southern Ethiopia. *Geoderma, 290*, 40–50. https://doi.org/10.1016/j.geoderma.2016.11.021

Olsen, S. R., Cole, C. V., Watanabe, F. S., & Dean, L. A. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (USDA Circular No. 939). https://naldc.nal.usda.gov/catalog/CAT87201102

Park, Y. W. (1996). Determination of moisture and ash contents of foods. In L. M. L. Nollet (Ed.), *Handbook of food analysis* (pp. 59–92). Marcel Dekker, Inc. https://www.google.com/books/edition/Handbook_of_Food_Analysis_Volume_1/v_9pQgAACAAJ

Rajasekar, M., Nandhini, D. U., & Suganthi, S. (2017). Supplementation of mineral nutrients through foliar spray – A review. *International Journal of Current Microbiology and Applied Sciences*. https://doi.org/10.20546/ijcmas.2017.603.283

Rassaei, F. (2023). *Phosphorus in soils and plants*. LAP LAMBERT Academic Publishing. https://www.morebooks.shop/shop-ui/shop/book-details/9786207447374

Schoenholtz, S. H., Van Miegroet, H., & Burger, J. A. (2000). A review of chemical and physical properties as indicators of forest soil quality: Challenges and opportunities. *Forest Ecology and Management, 138*(1–3), 335–356. https://doi.org/10.1016/S0378-1127(00)00423-0

Sikora, L. J., & Stott, D. E. (1996). Soil organic carbon and nitrogen. In J. W. Doran & A. J. Jones (Eds.), *Methods for assessing soil quality* (SSSA Special Publication 49, pp. 157–167). Soil Science Society of America. https://doi.org/10.2136/sssaspecpub49.c9

Srivastava, N., & Rajwar, G. S. (2021). Study on physical and chemical properties of soil on growth and morphogenesis of plant species of Kumaun region, Uttarakhand. *International Journal of Creative Research Thoughts, 9*(1), 4482–4486. https://ijcrt.org/viewfull.php?&p_id=IJCRT2101546

Terashima, M., & Mihara, M. (2022). Interactions among soil physical, chemical and biological properties under different farming systems. *International Journal of Environmental and Rural Development, 13*(1), 1–6. https://iserd.net/ijerd131/13-1-1.pdf

Tisdale, S. L., et al. (1997). *Soil fertility and fertilizers* (5th ed.). Macmillan Publishing Co.

Toth, S. J., & Prince, A. L. (1949). Estimation of cation-exchange capacity and exchangeable Ca, K, and Na contents of soils by flame photometer techniques. *Soil Science, 67*(6), 439–446. https://doi.org/10.1097/00010694-194906000-00003

Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science, 37*(1), 29–38. https://doi.org/10.1097/00010694-193401000-00003

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2026): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/158887