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RESEARCH ARTICLE

Pearson Correlation Study of Selected Soil Samples of the Eastern Region of Deoghar (PCSSSSERD)

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Abstract

Soil fertility and crop productivity are strongly controlled by soil physico-chemical properties and their interaction with nutrients. The present study was conducted to evaluate the nutrient status and interrelationships among soil properties of the eastern region of Deoghar district, Jharkhand, using Pearson correlation analysis. Surface soil samples were collected from five agricultural regions, namely Deoghar, Karon, Sarath, Palojori and Mohanpur and analysed for soil pH, electrical conductivity (EC), organic carbon (OC), available macronutrients (N, P, K), secondary nutrients (Ca, Mg, S) and micronutrients (Fe, Mn, Zn, Cu).

The soils were found to be slightly acidic to near neutral, with pH values ranging from 5.2 to 6.7, and non-saline, as EC values ranged between 0.20 and 0.40 dS m^{-1}. Organic carbon content was low to medium (0.15–0.65%), indicating moderate soil fertility. Available nitrogen and phosphorus showed wide variation, while potassium was present at medium to high levels. Calcium and magnesium contents varied moderately across the study area and micronutrient levels were mostly within permissible limits.

Pearson correlation analysis revealed strong and systematic relationships among soil properties and nutrients. Soil pH showed a very strong positive correlation with calcium (r = 0.964) and a negative correlation with iron and zinc, explaining frequent micronutrient deficiencies in crops. Electrical conductivity showed strong positive relationships with potassium and phosphorus, while organic carbon exhibited strong positive correlations with magnesium and zinc, highlighting its role in nutrient retention. Several antagonistic interactions among nutrients were also observed.

The study clearly demonstrates that soil pH, EC, organic carbon and nutrient interactions are the key factors controlling nutrient availability in the region. The findings provide a strong scientific basis for soil-test-based fertilizer recommendations, balanced nutrient management and sustainable agricultural practices, which can help improve crop productivity and soil health in the eastern region of Deoghar district.

Keywords: Soil fertility, Pearson correlation, Nutrient availability, Soil pH, Organic carbon, Electrical conductivity, Micronutrients, Eastern Region of Deoghar district, Agricultural soil.

Introduction

Soil is the foundation of agriculture and the success of farming largely depends on the health and quality of soil. Healthy soil provides essential nutrients, adequate water and proper physical support required for the growth and development of crops(Xing et al., 2025)(Priya et al., 2024). However, soil fertility is not determined only by the total amount of nutrients present in the soil. It is also strongly influenced by various soil properties such as soil pH, salinity, organic matter content and calcium compounds. These properties control how nutrients behave in the soil and how easily plants can absorb them(Priya et al., 2024). Even when nutrients are present in sufficient quantities, unfavourable soil conditions can reduce their availability to crops, leading to poor growth and low yields(Li et al., 2025).

In many regions of Jharkhand, including the Deoghar district, farmers commonly face the problem of low crop productivity. This issue is often linked to poor soil fertility rather than climatic factors alone(D. Kumar, 2022). In most cases, the problem is not the complete absence of nutrients but an imbalance among them. Similarly, low organic matter content affects the soil's ability to hold nutrients and water, making crops more vulnerable to nutrient stress. As a result,

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crops may show deficiency symptoms even when fertilizers are applied, leading to inefficient use of agricultural inputs and increased costs for farmers(Mandal Tirthankar, 2024).

To understand these complex interactions, it is important to study how different soil properties are related to one another. Pearson correlation is a simple and widely used statistical method that helps in identifying the strength and direction of relationships between two variables (Kumar, A.et al., 2024). In soil science, this method is useful for understanding how changes in one soil property, such as pH, influence the availability of nutrients like nitrogen, phosphorus, potassium and micronutrients. Positive correlation indicates that both properties increase together, while negative correlation shows that an increase in one property leads to a decrease in another(Kumar, A. et al., 2023).

The present study was carried out to examine the relationships among various soil properties and nutrients in the eastern region of Deoghar district. By using Pearson correlation analysis, the study aims to identify key soil factors that control nutrient availability in this region. The findings are expected to help farmers, soil scientists and agricultural planners in understanding soil behaviour more clearly. This knowledge can support better soil management practices, balanced fertilizer application and improved crop productivity, ultimately contributing to sustainable agriculture in the Deoghar region.

Geology

Deoghar district (Fig.1 & Fig.2) is situated in the north-eastern part of Jharkhand and forms a part of the Chotanagpur Plateau, which is one of the oldest geological regions of India. The geology of the district is dominated by Precambrian crystalline rocks. The main rock types found in the area include granite, granite gneiss, schist and quartzite. Granite and gneiss are the most widespread formations and are rich in quartz and feldspar minerals(Srivastava et al., 2020). These hard rocks undergo slow weathering, which results in the formation of light-textured soils. Schist formations, containing mica and other secondary minerals, occur in limited patches and contribute to slightly finer soil textures. Quartzite, being highly resistant to weathering, gives rise to shallow and less fertile soils. Fractures, joints and lineaments are common geological features and play an important role in groundwater storage and movement, as the area lacks major sedimentary aquifers(ADCC, Infocad Private Limited, 2009).

Soil Nature

The soils of Deoghar district are mainly derived from the weathering of crystalline rocks and are generally sandy loam in texture. Soil depth varies from shallow to medium depending on topography and parent material(ADCC Infocad Private Limited, 2009). Soil reaction ranges from slightly acidic, with pH values commonly between 5.2 and 6.7(ADCC, Infocad Private Limited, 2009).

Study Area

The present study was carried out in the eastern region of Deoghar district (Fig- 1), covering five agricultural regions: Deoghar, Karon, Sarath, Palojori and Mohanpur. These regions represent different soil types, land use patterns and cropping systems of the district. Agriculture in the study area mainly depends on monsoon rainfall, with crops such as paddy, wheat, maize, pulses and oilseeds being commonly grown. The selected study area provides a suitable representation of the regional soil variability, making it ideal for evaluating soil properties, nutrient status and their interrelationships for better soil and crop management.

Soil samples were collected from cultivated agricultural fields from five locations of the eastern region of Deoghar district, namely Deoghar, Karon, Sarath, Palojori and Mohanpur (Figures 3-7). These areas represent typical farming areas of the region and were selected to understand the general soil condition influencing crop production. Surface soil samples were collected from the plough layer, as this layer is most active for plant root growth and nutrient uptake. After collection, the soil samples were air-dried under shade to remove moisture, gently crushed and passed through a fine sieve to obtain uniform samples suitable for laboratory analysis(Mabit et al., 2018)(*Soil Sampling & Testing Manual)*(*Soil Sampling (Disturbed and Undisturbed), (Handling and Storage for Soil Chemical, Biological and Physical Properties*).

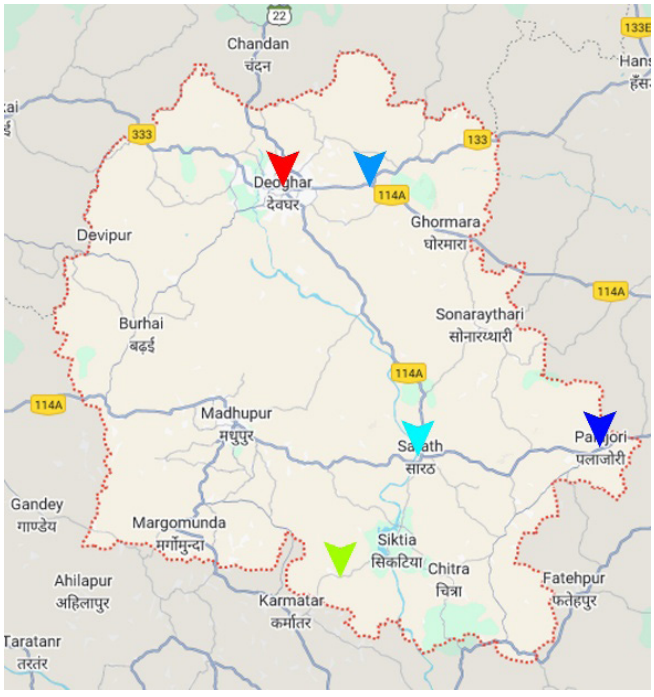

Figure 1: Sampling Sites of Eastern region of Deoghar

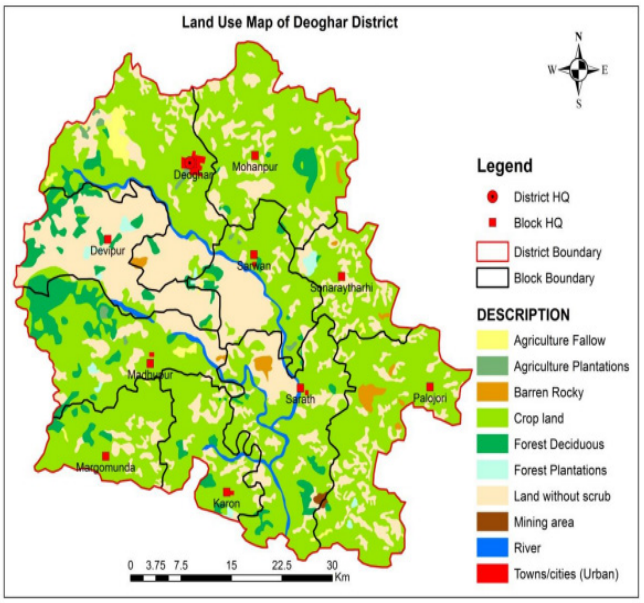

Figure 2: District Map of Deoghar

The prepared soil samples were analyzed for a wide range of physical and chemical properties to assess soil fertility and nutrient behaviour at Precision Laboratories, Kolkata. Soil pH was measured to determine whether the soils were acidic, neutral or alkaline, as pH plays a major role in controlling nutrient availability. The organic matter status of the soils analyzed, which influences nutrient supply, soil structure and microbial activity(Tagami & Uchida, 2025),(Iffat Alam et al., 2020).

To assess soil fertility, available nitrogen, phosphorus and potassium were analyzed, as these are the primary nutrients required for crop growth(Kulkarni et al., 2014). These parameters are closely related to soil structure, nutrient balance and plant root environment. The availability of certain nutrients, especially micronutrients will(Dorlikar et al., 2025) be very helpful in the different types of agroecosystems.

Pearson correlation coefficients were calculated among all soil properties and nutrient parameters to study their interrelationships(Kumar, A. et al., 2023), (Kumar, A. et al., 2024). Strong positive and negative correlations were considered statistically significant and agriculturally meaningful, as they help identify key soil factors controlling nutrient availability and guide better soil and fertilizer management practices in the region(Kumar, A.et al., 2022).

Table 1: Sampling Location & Texture of Eastern region of Deoghar. Materials and Methods

S. No	*Sample place*	*Sample colour*	*Latitude*	*Longitude*
1.	Deoghar	Blackish Red	24.48518	86.69478
2.	Karon	Yellowish Red	24.12577	86.74541
3.	Sarath	Greenish Yellow	24.2346	86.83835
4.	Palojori	Light Red	24.1242	86.95865
5.	Mohanpur	Yellowish Grey	24.49315	86.78436

Pearson Correlation

Pearson correlation is a widely used statistical technique for measuring the degree and direction of linear association between two quantitative variables(Berman, 2016). It is especially useful in scientific research for understanding relationships among variables without implying direct causation. In soil science and agricultural research, Pearson correlation helps in identifying how soil physico-chemical properties influence the availability and behaviour of nutrients(Negiş et al., 2025),(Kumar, A.et al., 2024).

The Pearson correlation coefficient, denoted by r, ranges from –1 to +1. A value of +1 indicates a perfect positive linear relationship, where both variables increase together. A value of –1 indicates a perfect negative linear relationship, where an increase in one variable results in a proportional decrease in the other. A value of 0 indicates the absence of a linear relationship between the variables (Kumar, A. et al., 2024). Mathematically, the Pearson correlation coefficient is expressed as:

$$r=\frac{\Sigma(X-\bar{X})(Y-\bar{Y})}{\sqrt{\Sigma(X-\bar{X})^2\,\Sigma(Y-\bar{Y})^2}} \qquad \text{Equ}^{n}\ 1$$

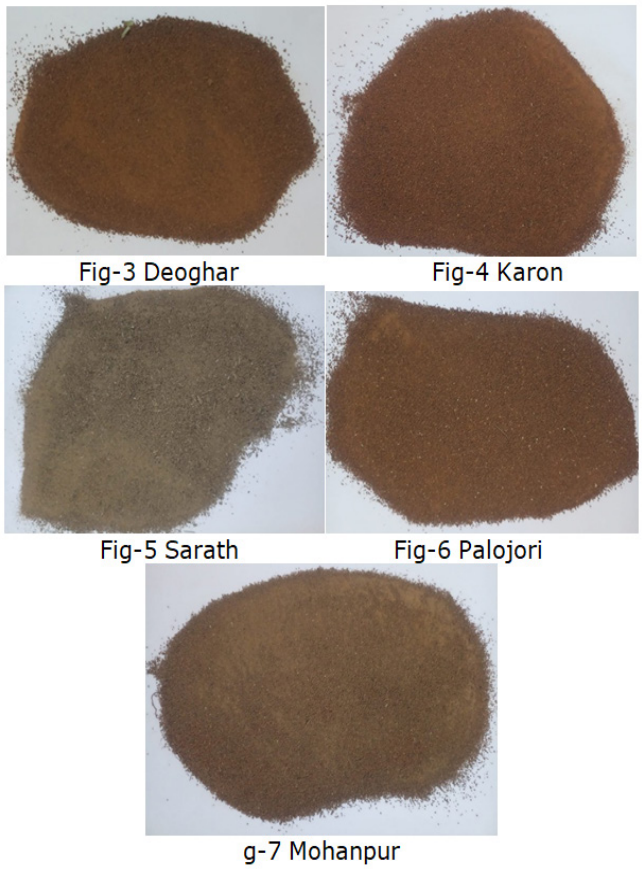

Figure 3: Different Soil Samples of Eastern region of Deoghar

Table 2: Correlation Parameters of Eastern region of Deoghar.

	pH	*EC*	*OC*	*N*	*P*	*K*	*Ca*	*Mg*	*Fe*	*Mn*	*Zn*	*Cu*	*S*
pH	1												
EC	0.076	1											
OC	-0.564	0.527	1										
N	0.058	0.275	-0.417	1									
P	0.046	0.580	-0.181	0.907	1								
K	0.544	0.860	0.262	0.090	0.363	1							
Ca	0.964	0.289	-0.509	0.260	0.293	0.676	1						
Mg	-0.222	0.144	0.758	-0.893	-0.666	0.177	-0.324	1					
Fe	-0.517	-0.687	-0.095	-0.365	-0.399	-0.795	-0.652	0.164	1				
Mn	0.658	0.308	0.196	-0.503	-0.390	0.684	0.587	0.510	-0.567	1			
Zn	-0.205	0.444	0.892	-0.688	-0.445	0.413	-0.229	0.924	-0.174	0.584	1		
Cu	0.054	0.606	0.014	0.823	0.784	0.415	0.277	-0.568	-0.750	-0.118	-0.213	1	
S	-0.311	-0.891	-0.103	-0.546	-0.810	-0.828	-0.540	0.222	0.652	-0.164	-0.032	-0.654	1

Equation 1 Pearson Correlation

where X and Y represent the two variables under study, and $\overline{X}$ and $\overline{Y}$ are their respective mean values (Kumar, A. et al., 2024), (Kumar, A. et al., 2023), (Kumar, A. et al., 2022).

Pearson correlation analysis assumes that the variables are continuous, normally distributed and linearly related. The data should be free from extreme outliers, as such values can strongly influence the correlation coefficient. The strength of correlation is generally interpreted as strong ($|r| \geq 0.70$), moderate ($|r| = 0.40–0.69$), or weak ($|r| = 0.10–0.39$).

In soil fertility studies, Pearson correlation is applied to evaluate relationships between soil properties such as pH, electrical conductivity, organic carbon and nutrients including nitrogen, phosphorus, potassium and micronutrients. Positive correlations suggest that an increase in one parameter enhances the other, while negative correlations indicate an inverse relationship. These associations help explain nutrient availability, deficiency trends, and soil behaviour under different chemical conditions (Kumar, A. et al., 2024).

Although Pearson correlation provides valuable insights into variable relationships, it does not establish cause-and-effect relationships. Nevertheless, it remains a reliable and effective statistical tool for interpreting soil data and supporting soil-test-based nutrient management strategies in agricultural research.

Results and Discussion

Effect of pH

The soil samples collected from Deoghar, Karon, Sarath, Palojori and Mohanpur. Soil pH ranged from 5.2 to 6.7 (Fig-8), indicating slightly acidic to near-neutral soils, which are generally favorable for nutrient availability and crop growth. (Govasmark et al., 2005) (Kumar, A. et al., 2024) The lowest

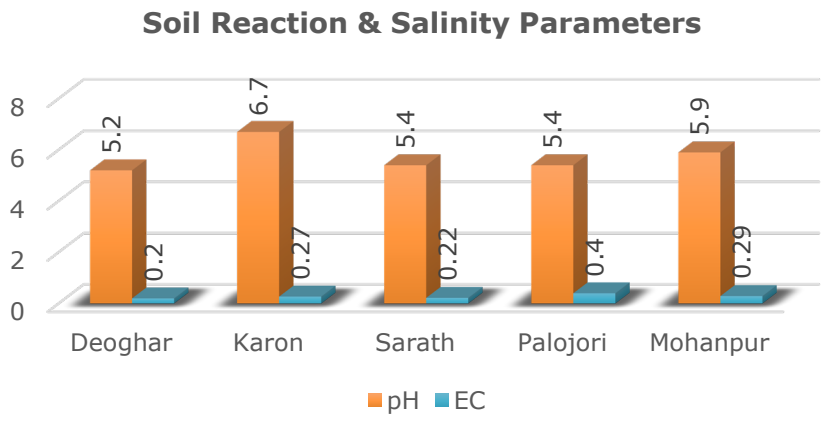

Figure 4: Soil Reaction & Salinity Parameters of Eastern region of Deoghar.

pH was observed in Deoghar (5.2), while Karon recorded the highest pH (6.7)(Aziz Alaie & Gupta, 2019)(ADCC, Infocad Private Limited, 2009).

Effect of EC

Electrical conductivity (EC) values varied between 0.20 and 0.40 dS m^{-1} (Fig-8), confirming that all soils were non-saline in nature. Such low EC values indicate the absence of salt stress and suitability for agricultural use.

Effect of OC

Organic carbon (OC) content ranged from 0.15 to 0.65%, showing low to medium organic matter status. Higher OC was recorded in Palojori and Mohanpur (0.65%) (Fig-9), which supports better nutrient retention and microbial activity(Ozlu & Kumar, 2018)(Aziz Alaie & Gupta, 2019).

Effect of Organic Matter & Primary Nutrient

Available nitrogen (N) ranged from 120 to 270 kg ha^{-1}, showing low to medium fertility status. Mohanpur showed the lowest nitrogen content, suggesting the need for nitrogen supplementation. Available phosphorus (P) varied widely from 8.2 to 21.7 kg ha^{-1}, with the lowest value again in Mohanpur, indicating phosphorus deficiency in certain locations. Potassium (K) levels ranged from 145 to 265 kg ha^{-1}(Fig- 9, reflecting medium to high availability across the study area (Kumar, A. et al., 2024), (*Soil Analysis Results and Interpretation)*.

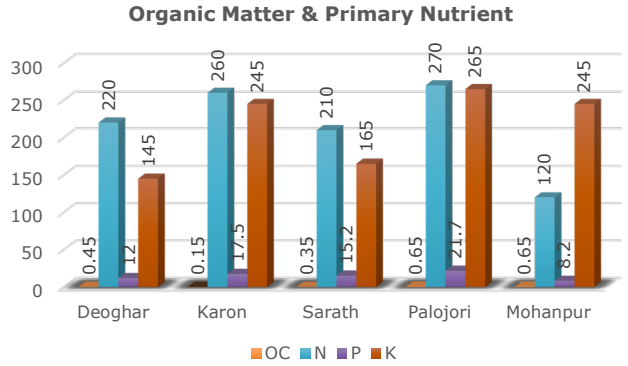

Figure 5: Organic Matter & Primary Nutrient present in the soil sample of Eastern region of Deoghar

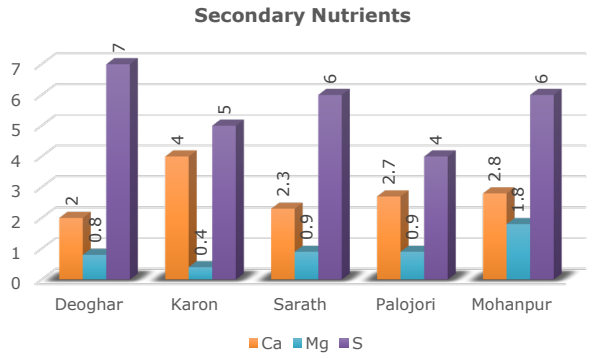

Figure 6: Secondary Nutrients present in the soil sample of Eastern region of Deoghar

Effect of Secondary & MicroNutrients

Calcium (Ca) and magnesium (Mg) contents showed moderate variation. Calcium ranged from 2.0 to 4.0, while magnesium ranged from 0.4 to 1.8, with Mohanpur showing relatively higher Mg content. Among micronutrients, iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu), (Fig-10) were mostly within permissible limits, though Zn and Cu showed higher (Fig-11) accumulation in Palojori and Mohanpur (Kumar, A. et al., 2024), (*Soil Analysis Results and Interpretation*), (Govasmark et al., 2005).

The Pearson correlation matrix (Table 2) revealed strong interrelationships between soil properties and nutrient availability, highlighting the controlling role of soil chemistry in nutrient dynamics (Kumar, A. et al., 2024), (Kumar, A. et al., 2022).

Table 2 emphasis on different Pearson Correlation chart for the present investigation.

Pearson Correlation Study of pH

Soil pH showed a very strong positive correlation with calcium (r = 0.964), (Table- 2) indicating that higher pH favors calcium accumulation in soils. pH also showed a positive correlation with potassium (r = 0.544) and manganese (r = 0.658), suggesting improved availability of these nutrients under slightly acidic to near-neutral conditions. However, pH was negatively correlated with organic carbon (r = −0.564) and iron (r = −0.517), showing that acidic soils tend to retain more organic matter and iron.

Pearson Correlation Study of EC

Electrical conductivity (EC) exhibited strong positive correlations with potassium (r = 0.860), phosphorus (r = 0.580), zinc (r = 0.444), (Table- 2) and copper (r = 0.606). This indicates that dissolved salts in soil solution influence the mobility and availability of nutrients. A strong negative correlation between EC and sulphur (r = −0.891) suggests sulphur depletion under higher soluble salt conditions.

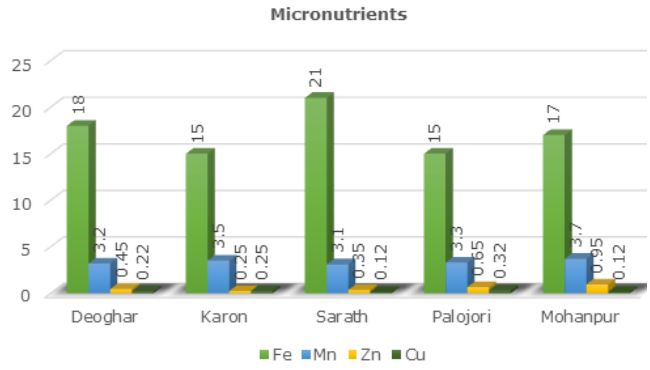

Figure 7: Micronutrients present in the soil sample of Eastern region of Deoghar

Pearson Correlation Study of Organic Carbon

Organic carbon played a crucial role in nutrient retention. OC showed strong positive correlations with magnesium (r = 0.758) and zinc (r = 0.892), (Table- 2) confirming that organic matter enhances micronutrient availability through chelation and improved soil structure. However, OC was negatively correlated with nitrogen (r = −0.417) and calcium (r = −0.509), reflecting nutrient immobilization or biological competition in organic-rich soils.

Pearson Correlation Study of Available Nitrogen

Available nitrogen showed a very strong positive correlation with phosphorus (r = 0.907) and copper (r = 0.823), (Table- 2) suggesting common sources or similar management practices. Nitrogen had a strong negative correlation with magnesium (r = −0.893) and zinc (r = −0.688), indicating possible nutrient antagonism.

Pearson Correlation Study of Fe

Iron showed strong negative correlations with potassium (r = −0.795), calcium (r = −0.652) and copper (r = −0.750), (Table- 2) which suggests reduced iron availability in calcium- and potassium-rich soils, a common phenomenon in well-aerated agricultural soils. Zinc and magnesium were very strongly correlated (r = 0.924), highlighting their linked behaviour in soil systems.

Pearson Correlation Study of S

Sulphur showed strong negative correlations with EC (r = −0.891), potassium (r = −0.828) and phosphorus (r = −0.810), (Table- 2) indicating sulphur depletion in intensively fertilized soils where macronutrient dominance exists.

From the above results the soil pH, organic carbon and electrical conductivity are the key controlling factors governing nutrient availability in the soils of the Deoghar region. Positive and negative correlations reflect both synergistic and antagonistic interactions among nutrients. These findings emphasize the need for balanced fertilization, organic matter management and micronutrient supplementation for sustainable soil fertility and improved crop productivity.

Agricultural Importance of the Study

The present study is highly important from an agricultural point of view because it clearly explains how soil physico-chemical properties control nutrient availability in the eastern region of Deoghar district. Farmers in this region often apply fertilizers without prior knowledge of soil condition, which results in low fertilizer efficiency, poor crop response and increased input cost. The findings of this study help explain why certain nutrients remain unavailable to crops even when their total concentration in soil appears adequate.

The results (Table- 2) show that soil pH ranged from 5.2 to 6.7, indicating slightly acidic to near-neutral soils. Pearson correlation analysis revealed that soil pH had a strong positive relationship with calcium (r = 0.964) and potassium (r = 0.544), while it showed a negative relationship with iron (r = −0.517) and zinc (r = −0.205). This confirms that as soil pH increases towards neutrality, the availability of micronutrients such as Fe and Zn decreases.

Organic carbon content was low to medium (0.15–0.65%), indicating the need for improved organic matter management. Organic carbon showed a strong positive correlation with magnesium (r = 0.758), (Table-2) and zinc (r = 0.892), demonstrating that organic matter plays a crucial role in enhancing micronutrient availability through chelation and improved nutrient retention. Therefore, the application of farmyard manure, compost, green manure and crop residues is essential for improving soil fertility and sustaining long-term productivity.

The study also highlights the importance of soil nutrient-holding capacity. Potassium exhibited a very strong positive correlation with electrical conductivity (r = 0.860) and calcium (r = 0.676), (Table- 2) indicating that soils with better chemical balance and exchange capacity supply potassium more efficiently to crops. This helps farmers apply appropriate potassium fertilizer doses and avoid unnecessary overuse.

The present investigation strongly supports soil-test-based fertilizer recommendations, balanced nutrient management and sustainable agricultural practices. Adoption of these findings can help farmers improve crop yield, reduce fertilizer wastage, lower production costs and maintain soil health in the Deoghar region.

Conclusion

The present study based on physico-chemical analysis and Pearson correlation of soils from the eastern region of Deoghar district clearly shows that soil properties and nutrient availability are strongly interlinked. The soils were slightly acidic to near neutral (pH 5.2–6.7) and non-saline (EC 0.20–0.40 dS m^{-1}). Soil pH showed strong positive relationships with calcium and moderate positive links with potassium and manganese, but negative correlations with iron, zinc and organic carbon, explaining common micronutrient deficiencies in calcium-influenced soils. Electrical conductivity was positively associated with potassium, phosphorus, zinc and copper, but negatively with sulphur, indicating nutrient mobility and sulphur depletion patterns. Organic carbon (0.15–0.65%) improved magnesium and zinc availability but showed negative associations with nitrogen, phosphorus and calcium, suggesting possible nutrient immobilization. Nitrogen had a strong positive correlation with phosphorus and copper but negative relationships with magnesium and zinc, indicating nutrient imbalance under intensive fertilization. Potassium was positively influenced by pH, EC and calcium but negatively related to iron and sulphur, while calcium

dominance reduced iron and manganese availability. Strong micronutrient interrelationships were also observed, particularly between magnesium and zinc. Overall, the statistically significant correlations highlight the need for balanced fertilization, organic matter management and site-specific nutrient strategies to improve soil health and crop productivity in Deoghar district sustainably.

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