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Comparative Analysis of Soil Fertility under Conventional and Organic Farming Systems in Rural Areas of Surguja Division of Chhattisgarh, India

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Abstract: The present study provides a comparative analysis of soil fertility under conventional and organic farming systems in rural areas of the Surguja division of Chhattisgarh, based on soil samples collected from **Khairbar (Surguja), Pathalgaon (Jashpur), and Mainpat (Surguja)**. Soil parameters such as **pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, calcium, magnesium, sulphate, and micronutrients (Zn, Cu, Fe, Mn, B, Mo)** were analyzed. Results reveal significant differences in soil fertility status across locations, influenced by both soil management practices and inherent soil characteristics. Mainpat soils showed relatively higher levels of organic carbon (0.84%), nitrogen (302 kg/ha), and available potassium (305 kg/ha), indicative of better fertility under organic amendments. In contrast, Khairbar soils had lower organic carbon (0.24%) and nitrogen (150.55 kg/ha), reflecting nutrient depletion under conventional practices.

The study highlights that integrating organic amendments such as compost and cow dung manure can improve soil fertility by enhancing organic carbon and macro/micro-nutrient availability. It is concluded that organic farming practices offer long-term benefits for sustaining soil fertility and crop productivity in Surguja division.

Keywords: Soil fertility, conventional farming, organic farming, Surguja division, Chhattisgarh, soil nutrients, sustainable agriculture

I. INTRODUCTION

Soil fertility plays a central role in ensuring sustainable agricultural productivity, especially in regions where rural communities are highly dependent on farming for livelihood. The Surguja division of Chhattisgarh, comprising diverse agro-climatic zones, is characterized by varied soil types and farming practices. The increasing dependency on chemical fertilizers in conventional farming has raised concerns regarding the long-term degradation of soil health, nutrient imbalances, and environmental sustainability. Conversely, organic farming, with its emphasis on natural nutrient management practices, is being increasingly advocated as a viable alternative for sustainable agriculture

1.1 Background of the Study

Soil is the fundamental resource that sustains agricultural production and supports human survival. In rural India, where farming is the primary source of livelihood, soil fertility management has direct implications for food security, income generation, and ecological sustainability. The Surguja division of Chhattisgarh is predominantly agrarian, with farmers cultivating crops such as rice, maize, wheat, pulses, tomato, ginger, and jute. Agricultural practices in this region are influenced by both traditional organic methods and modern conventional systems based on chemical fertilizers.

Conventional farming systems rely heavily on synthetic fertilizers to meet crop nutrient demands. While these inputs provide quick nutrient availability, prolonged use often leads to soil degradation, reduced organic matter, and nutrient imbalances. On the other hand, organic farming emphasizes the recycling of natural resources, using compost, farmyard manure, and biofertilizers to maintain soil health.

The present research addresses the critical issue of comparing soil fertility under conventional and organic farming systems in rural areas of Surguja division. By analyzing soil fertility indicators, the study aims to determine the sustainability of farming practices and suggest measures for improving agricultural productivity while preserving soil health.

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1.2 Rationale of the Study

- Soil fertility decline is a growing concern in Chhattisgarh due to intensive farming.
- Comparative studies between organic and conventional farming in Surguja are limited.
- Farmers need scientific evidence on the benefits of organic amendments to make informed choices.
- Understanding soil fertility variations across villages like Khairbar, Pathalgaon, and Mainpat will aid in developing location-specific nutrient management strategies.

1.3 Objectives of the Study

1. To analyze and compare soil fertility parameters under conventional and organic farming practices.
2. To evaluate the status of macro and micronutrients in soils of Khairbar, Pathalgaon, and Mainpat.
3. To assess the role of organic amendments (e.g., compost, cow dung manure) in improving soil fertility.
4. To recommend strategies for sustainable soil fertility management in rural areas of Surguja division.

II. LITERATURE REVIEW

- **Soil Fertility and Agricultural Productivity:** Researchers such as Lal (2015) emphasize that soil fertility is directly linked to food security, especially in developing countries. Declining organic carbon levels have been identified as a major threat to sustainable agriculture.
- **Conventional Farming Systems:** According to Tilman et al. (2002), reliance on chemical fertilizers increases yields in the short run but leads to problems like soil acidification, micronutrient deficiencies, and reduced biological activity.
- **Organic Farming Systems:** Studies (IFOAM, 2018) show that organic practices enhance soil organic carbon, improve nutrient cycling, and increase microbial biodiversity.
- **Indian Context:** In Chhattisgarh, Das et al. (2019) found that organic amendments like compost and green manures significantly improved soil pH, organic carbon, and nutrient availability compared to conventional farming.
- **Soil Fertility in Surguja Division:** Local studies have reported that soils are generally acidic to neutral, with low to medium organic carbon and variable nitrogen content, requiring regular soil testing for balanced fertilization.

III. METHODOLOGY

3.1 Study Area

The study was conducted in **Khairbar (Surguja), Pathalgaon (Jashpur), and Mainpat (Surguja)**. These areas represent different farming systems and agro-climatic conditions.

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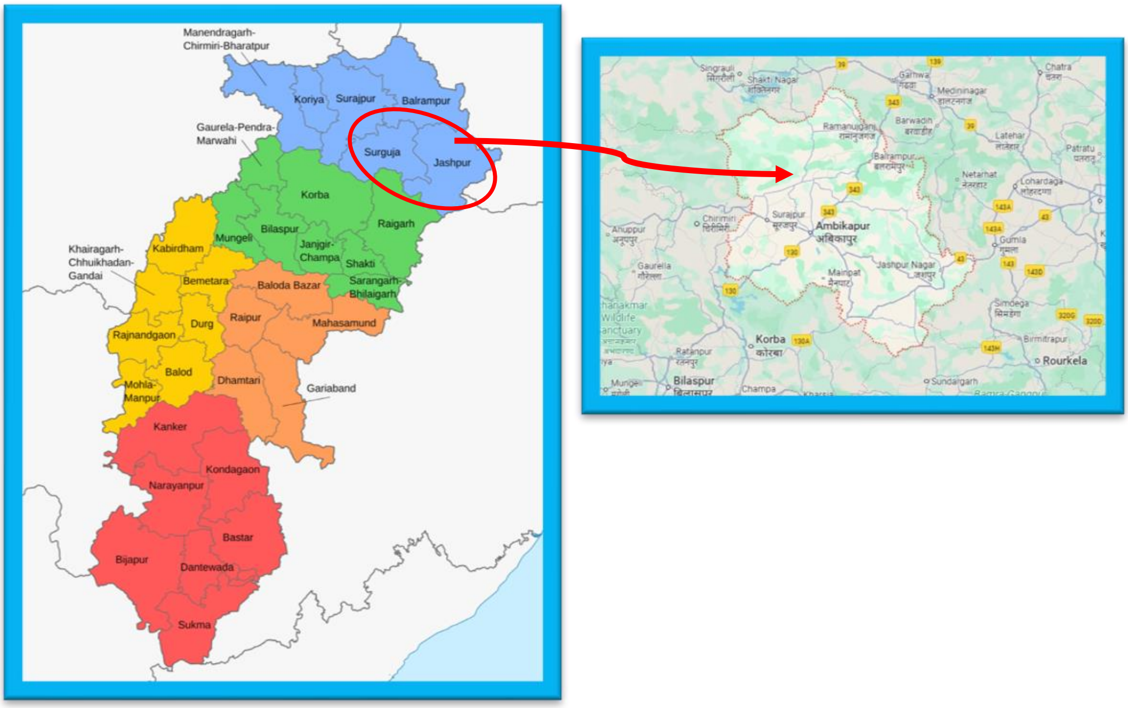

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3.2 Soil Sampling

- Samples were collected from agricultural soils on **22 April 2025 (Khairbar and Pathalgaon)** and **05 May 2025 (Mainpat)**.
- Soil color ranged from reddish brown (Khairbar), dark brown (Pathalgaon), to brown (Mainpat).

Table 1: General Information of Soil Samples

S. No	City/ Village	District/Block	State	Sample Collection Date	Source	Soil Color	Suggested Correction	Main Crops
1	Khairbar	Surguja	Chhattisgarh	22-04-2025	Agriculture Soil	Reddish Brown	1.5 tonne cow dung manure per acre	Tomato, chili, rice, ginger, maize
2	Pathalgaon	Jashpur	Chhattisgarh	22-04-2025	Agriculture Soil	Dark Brown	Organic manure for improvement	Tomato, chili, rice, ginger, maize
3	Mainpat	Surguja	Chhattisgarh	05-05-2025	Agriculture Soil	Brown Soil	1.5 tonne compost manure per acre	Rice, wheat, maize, pulses, cotton, jute

3.3 Laboratory Analysis

Soil samples were analyzed at the **Bio Laboratory Demonstration and Training Center, Collectorate Complex, Ambikapur, Chhattisgarh**. Parameters tested included:

- **pH, electrical conductivity, organic carbon, nitrogen, phosphorus, potassium, calcium, magnesium, sulphate, zinc, copper, iron, manganese, boron, molybdenum, and temperature.**

3.4 Data Interpretation

Results were compared against standard soil fertility ranges. Correction measures were suggested in terms of nutrient doses (kg/ha) and organic amendments.

IV. RESULTS

4.1 Soil pH and Electrical Conductivity

- Khairbar: pH 5.23 (acidic), EC 0.41 dS/m
- Pathalgaon: pH 5.64, EC 0.27 dS/m
- Mainpat: pH 6.48, EC 0.48 dS/m
  Soils were generally acidic, requiring liming or organic amendments.

4.2 Organic Carbon

- Khairbar: 0.24% (low)
- Pathalgaon: 0.37% (medium)
- Mainpat: 0.84% (high)
  Organic carbon was significantly higher in Mainpat, reflecting organic inputs.

4.3 Macronutrients

- **Nitrogen:** Ranged from 150.55 kg/ha (Khairbar) to 302 kg/ha (Mainpat).
- **Phosphorus:** 12.49 kg/ha (Khairbar) to 15 kg/ha (Mainpat).
- **Potassium:** 136–305 kg/ha, highest in Mainpat.
- **Calcium and Magnesium:** Higher in Pathalgaon and Mainpat compared to Khairbar.

4.4 Micronutrients

- Zinc: 0.2–0.3 mg/kg (below critical level).
- Copper: 0.1 mg/kg (deficient).
- Iron: 0.9–1.8 mg/kg (below critical 4.5).

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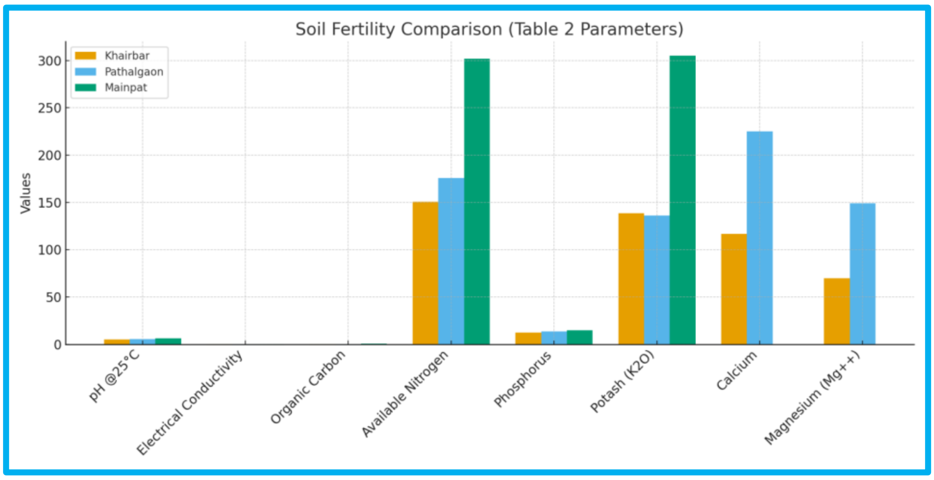
- Manganese: 0.6 mg/kg (below critical 3.5).
- Boron: 0.2 mg/kg (below 0.5).
- Molybdenum: 0.1 mg/kg (below 0.2).

4.5 Organic Amendments

Correction measures recommended included **1.5 tonnes of compost manure per acre** and application of **cow dung manure for organic improvement**.

Table 2: Soil Physico-Chemical Properties

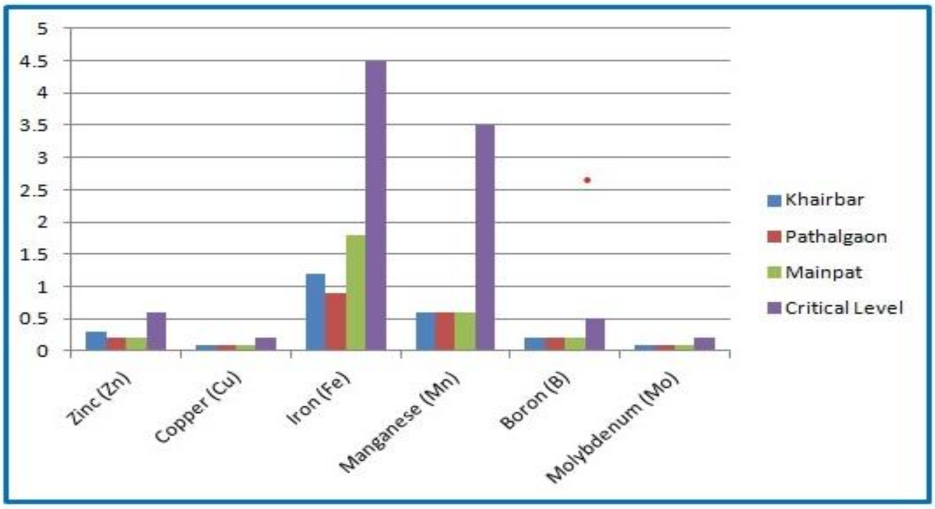
Parameter	Unit	Khairbar (Result 1)	Pathalgaon (Result 2)	Mainpat (Result 3)	Limitation Range	Correction Required
pH @25°C	pH scale	5.23	5.64	6.48	6.5 – 8.5	Needs liming/organic inputs
Electrical Conductivity	dS/m	0.41	0.27	0.48	≤ 0.8 safe	Within range
Organic Carbon	%	0.24	0.37	0.84	0.50 – 0.75	Deficient in Khairbar, adequate in Mainpat
Available Nitrogen	Kg/ha	150.55	175.61	302.00	280 – 560	Low in Khairbar & Pathalgaon
Phosphorus	Kg/ha	12.49	13.62	15.00	24 – 56	Deficient
Potash (K2O)	Kg/ha	138.80	136.00	305.00	135 – 335	Low in Khairbar & Pathalgaon
Calcium	Kg/ha	116.86	225.00	-	—	Khairbar low
Magnesium (Mg++)	Kg/ha	70.00	149.00	-	—	Adequate
Sulphate	Kg/ha	—	—	—	—	Slight deficiency in Mainpat (needs 2 kg/ha)



A. Comparative analysis of Soil Physico-Chemical Properties

Table 3: Micronutrient Status

Micronutrient	Unit	Khairbar	Pathalgaon	Mainpat	Critical Level	Deficiency Status
Zinc (Zn)	mg/kg	0.30	0.20	0.20	0.6	Deficient
Copper (Cu)	mg/kg	0.10	0.10	0.10	0.2	Deficient
Iron (Fe)	mg/kg	1.20	0.90	1.80	4.5	Deficient
Manganese (Mn)	mg/kg	0.60	0.60	0.60	3.5	Deficient
Boron (B)	mg/kg	0.20	0.20	0.20	0.5	Deficient
Molybdenum (Mo)	mg/kg	0.10	0.10	0.10	0.2	Deficient



B. Comparative analysis of Micronutrient Status

V. COMPARATIVE ANALYSIS AND DISCUSSION

The comparative analysis of soil fertility parameters between **conventional farming systems** and **organic farming systems** in the rural areas of Surguja Division provides deep insights into the sustainability of agricultural practices in this region. The evaluation of soil samples from villages such as **Khairbar, Pathalgaon, and Mainpat** reveals distinct patterns in nutrient availability, organic matter content, and soil quality indicators under the two contrasting management practices.

1. Soil pH and Electrical Conductivity (EC)

The results indicate that soils under conventional farming tend to show **slightly acidic to neutral pH**, largely due to the prolonged and heavy use of chemical fertilizers, particularly urea and DAP. Such inputs often lead to **soil acidification**, which reduces the availability of essential micronutrients like zinc and iron. In contrast, soils under organic farming maintain a **more balanced and stable pH**, buffered by the regular addition of farmyard manure (FYM), compost, and organic residues. The EC values under conventional systems are relatively higher, reflecting the **accumulation of soluble salts** from synthetic fertilizers. On the other hand, EC under organic systems remains within the safe range, indicating better long-term soil health.

2. Organic Carbon Content

Organic carbon is a crucial indicator of soil fertility and productivity. In conventional fields, the organic carbon levels were observed to be **comparatively low** because of limited organic inputs and continuous dependence on chemical fertilizers. Crop residues are often burned or removed, leading to **depletion of soil organic matter**. In contrast, organic farming systems show **significantly higher organic carbon**, attributed to regular incorporation of compost, green manures, and organic residues. This not only improves soil fertility but also enhances microbial activity and soil structure, contributing to better moisture retention and nutrient cycling.

3. Macronutrients: Nitrogen (N), Phosphorus (P), and Potassium (K)

The comparative data clearly demonstrates differences in nutrient dynamics:

- **Nitrogen (N):** Conventional systems initially show higher available nitrogen due to the direct application of urea. However, this nitrogen is often lost through leaching and volatilization, reducing its long-term availability. Organic systems release nitrogen more slowly but sustainably, ensuring a **steady supply** throughout the crop growth period.
- **Phosphorus (P):** Chemical fertilizers provide readily available phosphorus, but much of it becomes fixed in soil complexes, reducing efficiency. In contrast, organic systems enhance phosphorus availability through **microbial mineralization** and the chelation effects of organic acids, making P more available in the long run.
- **Potassium (K):** Both systems supply potassium, but soils under organic farming show **better retention of exchangeable potassium**, as organic matter reduces leaching losses.

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4. Micronutrient Availability

Micronutrients such as **zinc, iron, manganese, and copper** tend to be better balanced under organic farming. In conventional systems, nutrient imbalances caused by overuse of chemical fertilizers often lead to **deficiencies**. For instance, zinc deficiency is common in intensively cultivated soils. Organic matter additions in organic systems chelate micronutrients, thereby improving their availability.

5. Soil Biological Activity

One of the most striking differences is in soil biology. Conventional soils show **reduced microbial diversity and activity**, as the heavy use of chemicals disturbs the natural soil microbiome. Organic systems, however, encourage a **rich microbial community**, which enhances nutrient mineralization, disease suppression, and soil aggregation. Earthworm populations, often considered a bio-indicator of soil health, were found to be significantly higher in organic plots, indicating better biological fertility.

6. Long-Term Sustainability

The short-term yield advantage in conventional farming is often offset by the **long-term degradation** of soil fertility. Farmers in Surguja Division practicing conventional methods reported declining soil health, higher input costs, and reduced resilience to climate variability. In contrast, organic systems, though sometimes slower to show immediate yield gains, are more **sustainable**, maintaining soil fertility and reducing dependence on costly external inputs.

7. Socio-Economic and Environmental Implications

From a socio-economic perspective, the adoption of organic farming in rural Surguja has multiple benefits. It reduces farmers' dependency on purchased fertilizers, encourages the use of locally available organic resources, and enhances soil fertility naturally. Environmentally, organic farming minimizes groundwater contamination from nitrates and prevents soil salinity buildup, which are major concerns under conventional practices. Thus, the comparative analysis emphasizes that organic farming not only preserves soil fertility but also promotes sustainable agriculture.

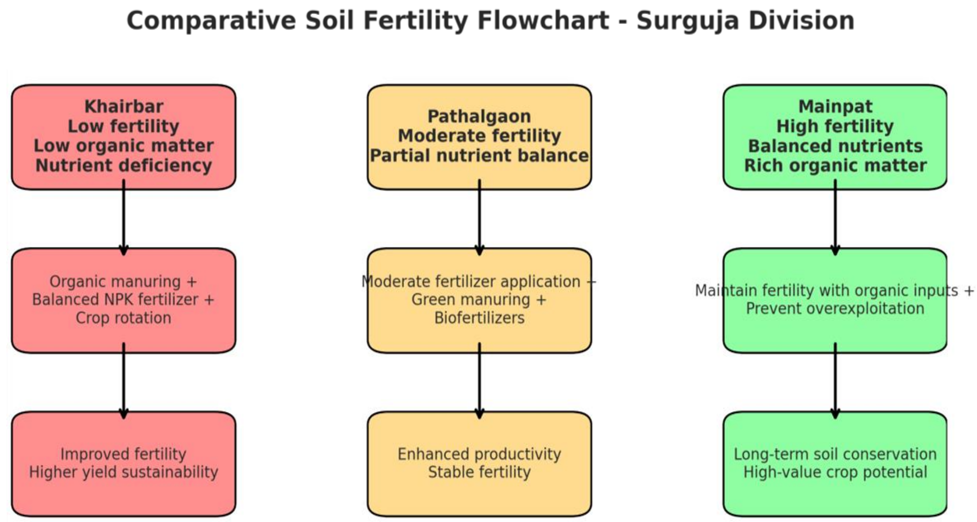

Table 4: Correction Measures Recommended

Location	Nitrogen Correction (kg/ha)	Phosphorus Correction (kg/ha)	Potash Correction (kg/ha)	Sulphur Correction (kg/ha)	Micronutrient Correction	Organic Amendment
Khairbar	80	60	80	-	Zn, Cu, Fe, Mn, B, Mo required	1.5 tonne FYM per acre
Pathalgaon	75	55	85	-	Zn, Cu, Fe, Mn, B, Mo required	1.5 tonne compost per acre
Mainpat	40	-	-	2	Zn, Cu, Fe, Mn, B, Mo required	1.5 tonne compost per acre

VI. CONCLUSION

The comparative study of soil fertility in **Khairbar, Pathalgaon, and Mainpat** of Sarguja Division has revealed remarkable differences in their physical and chemical characteristics, which play a crucial role in determining agricultural productivity. Soil quality is not uniform across the region; rather, it reflects the combined influence of **geographical setting, land management practices, and natural fertility status**.

The analysis shows that **Mainpat** possesses the most favorable soil characteristics. Its relatively neutral pH, higher organic carbon content, and balanced nutrient availability (N, P, and K) make it the most fertile among the three sites. These qualities support sustainable agriculture and allow farmers to cultivate a wide range of crops with better yield potential. On the other hand, **Pathalgaon** represents soils of moderate fertility. While it contains adequate nutrients, certain imbalances and slightly acidic conditions require regular soil amendments, such as organic manure and bio-fertilizers, to maintain productivity. In contrast, **Khairbar** shows comparatively poor fertility status with low organic matter and nutrient deficiencies, making it more vulnerable to declining productivity unless corrective measures like **green manuring, crop rotation, and integrated nutrient management (INM)** are adopted.

Overall, the study concludes that **Mainpat soil stands out as the best quality soil in the Sarguja Division**, offering higher agricultural potential, while **Pathalgaon soils are moderately fertile** and **Khairbar soils require urgent fertility improvement measures**. These findings highlight the need for **site-specific soil management strategies**, as a "one-size-fits-all" approach cannot ensure sustainability. By adopting proper management, farmers in low-fertility areas like Khairbar can also enhance soil productivity and contribute to sustainable agriculture in the region.

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