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Short Communication

An impact analysis of Rhizosphere and non Rhizosphere soil on wheat crop in Sirsa City, Haryana, India

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Abstract

Soil composition plays a crucial role in plant growth, particularly in the rhizosphere, where root-microbe interactions enhance nutrient availability and microbial activity. This study evaluates the comparative impact of rhizosphere and non-rhizosphere soil on wheat (Triticum aestivum) growth in Sirsa City, Haryana. Soil samples were analyzed for key physicochemical properties, microbial populations, and nutrient availability. Additionally, wheat growth parameters, including germination rate, plant height, biomass, and grain yield, were assessed. Results indicate that rhizosphere soil exhibited higher organic matter content (2.5% vs. 1.8%), microbial population (2.1×10^{6} CFU/g vs. 0.8×10^{6} CFU/g), and essential nutrients (nitrogen, phosphorus, and potassium) compared to non-rhizosphere soil. These differences led to a significant improvement in wheat growth, with a 21.6% increase in grain yield under rhizosphere conditions. The findings highlight the critical role of soil biological properties in sustainable wheat farming and suggest that microbial enhancement strategies could further optimize soil fertility and crop productivity.

Keywords: Rhizosphere, Non-Rhizosphere, Wheat Growth, Soil Microbiology, Nutrient Dynamics.

Introduction

Soil is a fundamental component of agricultural ecosystems, influencing plant growth through its physical, chemical, and biological properties. One of the most biologically active zones in soil is the rhizosphere, the narrow region surrounding plant roots where complex interactions occur between soil, microbes, and plant exudates. In contrast, non-rhizosphere soil is not directly influenced by root activity and exhibits lower microbial diversity and nutrient availability. Understanding the differences between these soil zones is essential for improving crop productivity and soil fertility management.

Wheat (*Triticum aestivum*), a staple crop for global food security, requires optimal soil conditions for maximum yield. The rhizosphere plays a crucial role in wheat growth by fostering beneficial microbial communities that enhance nutrient solubilization, nitrogen fixation, and organic matter decomposition. These interactions contribute to increased nutrient availability, which is essential for plant development. Several studies have demonstrated that rhizosphere soil supports higher microbial populations and enzymatic activities compared to non-rhizosphere soil, ultimately improving crop performance[1,2].

Sirsa City, Haryana, is a major wheat-producing region in India, characterized by alluvial loam soil and semi-arid climatic conditions. However, variations in soil microbial composition and nutrient distribution can significantly impact wheat yield. Despite the well-established importance of rhizosphere dynamics, limited research has been conducted on its specific impact on wheat growth in this region.

This study aims to compare the physicochemical properties, microbial activity, and nutrient availability of rhizosphere and non-rhizosphere soils in Sirsa City and evaluate their effects on wheat growth and yield. By analyzing key soil parameters and wheat performance indicators, this research provides valuable insights into soil-plant interactions and highlights the potential benefits of enhancing rhizosphere conditions for sustainable wheat production.

Materials and Methods

Study Area: The study was conducted in wheat fields located in Sirsa City, Haryana, which is a major wheat-producing region. The area experiences a semi-arid climate with an average annual rainfall of 300–400mm and a temperature range of 5°C to 45°C. The soil type predominantly consists of alluvial loam.

Soil Sampling: Soil samples were collected from multiple wheat fields at a depth of 0–15 cm. Two types of soil were analyzed: i. Rhizosphere soil: Collected from the immediate root zone of actively growing wheat plants. ii. Non-rhizosphere soil: Collected from areas at least 20 cm away from any wheat roots, ensuring no direct root influence.

Each sample was collected in sterile polyethylene bags, labeled, and transported to the laboratory for further analysis. Three replicates per field were taken to ensure accuracy.

Soil Physicochemical Analysis: i. pH Measurement: Soil pH was determined using a pH meter (1:2.5 soil-to-water suspension methods). ii. Organic Matter Content: Measured using the Walkley-Black method, which involves oxidation of organic carbon. iii. Nitrogen Content: Determined using the Kjeldahl method to measure total nitrogen. iv. Phosphorus Content: Measured using the Olsen's method (spectrophotometric analysis). v. Potassium Content: Determined by flame photometry using ammonium acetate extraction.

Microbial Analysis: i. Microbial Population: The total bacterial count was estimated using the serial dilution and plate count method on nutrient agar. Colony-forming units (CFU/g) were calculated. ii. Microbial Activity: Evaluated using dehydrogenase enzyme activity, which indicates overall microbial metabolic activity in the soil.

Wheat Growth Assessment: To determine the effect of soil type on wheat crop growth, the following parameters were measured: i. Germination Rate: Recorded as the percentage of seeds germinated after 7 days of sowing. ii. Plant Height: Measured using a ruler from the base to the tip of the tallest leaf at 30, 60, and 90 days after sowing. iii. Biomass Measurement: The total dry weight of plants was recorded after oven drying at 70°C for 48 hours. iv. Grain Yield: Wheat grains were harvested, weighed, and yield per hectare was calculated.

Statistical Analysis: All data were analyzed using ANOVA (Analysis of Variance) to determine significant differences between rhizosphere and non-rhizosphere soil. Mean values were compared using Tukey's HSD test ($p < 0.05$) for multiple comparisons. Data were processed using SPSS software (version 25.0).

Results and Discussion

The study compared rhizosphere and non-rhizosphere soil characteristics and their impact on wheat crop growth. The results showed significant differences in soil physicochemical properties, microbial activity, and plant growth parameters.

Soil Physicochemical Properties**:** The rhizosphere soil exhibited lower pH (6.8) compared to non-rhizosphere soil (7.2), indicating slightly more acidic conditions due to root exudates and microbial activity. Organic matter content was significantly higher in rhizosphere soil (2.5%) than in non-rhizosphere soil (1.8%), enhancing soil fertility.

Macro-nutrient analysis revealed that rhizosphere soil had higher nitrogen (50 mg/kg), phosphorus (25 mg/kg), and potassium (100 mg/kg) compared to non-rhizosphere soil (30 mg/kg, 15 mg/kg, and 70 mg/kg, respectively). This suggests that root-associated microbial activity improves nutrient cycling and availability.

Microbial Population and Activity**:** The microbial population was significantly higher in rhizosphere soil (2.1×10^6CFU/g) compared to non-rhizosphere soil (0.8×10^6CFU/g). This difference highlights the role of plant roots in promoting microbial colonization, which aids in nutrient solubilization and disease suppression.

Wheat Growth Performance**:** The wheat crop grown in rhizosphere soil showed better growth and yield parameters than in non-rhizosphere soil. The germination rate was 92% in rhizosphere soil, compared to 80% in non-rhizosphere soil. Plant height, biomass, and grain yield were also significantly higher in rhizosphere conditions, indicating improved nutrient uptake and root-microbe interactions.

Discussion: The findings confirm that rhizosphere soil enhances wheat growth due to improved microbial interactions and nutrient availability. The significant increase in nitrogen, phosphorus, and potassium in rhizosphere soil can be attributed to microbial processes such as nitrogen fixation, phosphorus solubilization, and organic matter decomposition. Similar findings have been reported by Bashan & de-Bashan and Richardson & Simpson, highlighting the role of beneficial microbes in enhancing soil fertility[1,2].

Table-1: Comparative Analysis

Parameter	Rhizosphere Soil	Non-Rhizosphere Soil	Percentage Increase in Rhizosphere
Soil Ph	6.8	7.2	-5.5% (more acidic)
Organic Matter (%)	2.5	1.8	+38.9%
Microbial Population (CFU/g)	2.1×10^6	0.8×10^6	+162.5%
Nitrogen (mg/kg)	50	30	+66.7%
Phosphorus (mg/kg)	25	15	+66.7%
Potassium (mg/kg)	100	70	+42.9%
Germination Rate (%)	92	80	+15%
Plant Height (cm)	75	65	+15.4%
Biomass (g/plant)	120	100	+20%
Grain Yield (kg/ha)	4500	3700	+21.6%

Higher microbial populations in rhizosphere soil suggest that root exudates create a favorable environment for microbial colonization, leading to increased nutrient cycling. The observed increase in plant height, biomass, and grain yield aligns with previous studies indicating that rhizosphere-associated microorganisms significantly improve plant health and productivity[3,4].

These results underscore the importance of maintaining a biologically rich rhizosphere for sustainable wheat farming. Future studies should explore microbial inoculation techniques to further enhance soil fertility and crop yield.

Conclusion

This study highlights the significant impact of rhizosphere soil on wheat (*Triticum aestivum*) growth and productivity in Sirsa City, Haryana. The findings reveal that rhizosphere soil, enriched with organic matter and beneficial microbial communities, exhibits superior nutrient availability and microbial activity compared to non-rhizosphere soil. These enhanced soil conditions contribute to improved wheat performance, resulting in higher germination rates, increased plant height, greater biomass accumulation, and a 21.6% boost in grain yield.

The study underscores the importance of root-microbe interactions in maintaining soil fertility and promoting sustainable agriculture. By fostering a biologically rich rhizosphere through microbial inoculation, organic amendments, and optimized soil management practices, farmers can significantly enhance crop productivity while reducing dependency on chemical fertilizers. Future research should explore advanced biotechnological approaches, such as plant growth-promoting rhizobacteria (PGPR) and mycorrhizal inoculants**,** to further optimize soil health and agricultural sustainability.
In an era where global food security is a growing concern, leveraging the natural potential of the rhizosphere presents a promising strategy for achieving resilient, high-yield, and environmentally sustainable wheat production.

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