



Assessment of Soil Nutrient Status under Different Cropping Systems in Rajnagar Block, Madhubani, Bihar

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This study assessed the soil nutrient status in Rajnagar Block, Madhubani, Bihar, under four main cropping systems: fallow-paddy, vegetable-vegetable, maize-mustard, and rice-wheat. In 20 representative fields, composite soil samples were taken at depths ranging from 0 to 20 cm. A range of 210 to 310 kg/ha of accessible nitrogen (N), 12.3 to 28.5 kg/ha of phosphorus (P), and 150 to 280 kg/ha of potassium (K) were found in the results. Phosphorus levels were somewhat lower in rice-wheat fields than in the vegetable-vegetable system, which had the greatest N and P values. With a pH range of 6.4 to 7.2, the soil was found to be mildly acidic to neutral. Under maize-mustard cultivation, the organic carbon content was highest, ranging from 0.48% to 0.72%. In order to maintain soil health in the area, the study emphasizes the necessity of integrated soil fertility techniques and site-specific nutrient management.

Keywords: Soil fertility, Cropping system, Rajnagar, Nutrient status, Bihar

Introduction

One of the most important natural resources for keeping life on Earth going is soil. It acts as a habitat for a variety of species, and a medium for plant growth, a regulator of water supply, and the reuse of basic materials. In the context of agriculture, soil is crucial for crop yield and sustainability because it gives plants the nutrients they need. However, in many regions of India, the health of the soil has significantly declined in recent decades due to factors like extensive agriculture, unsustainable agricultural methods, imbalanced fertilizer use, and growing population pressure.

The Indo-Gangetic plains, including Bihar, are a prime example of this, as growing input-intensive farming systems without appropriate nutrient replenishment mechanisms are replacing traditional farming methods. The agricultural environment of the North Bihar Plains, where agriculture is the primary source of income for the rural population, is represented by Rajnagar Block in the Madhubani district of Bihar. The area primarily uses a variety of farming techniques, including intensive vegetable cultivation, maize-mustard, and rice-wheat. In terms of input utilization, soil tillage intensity, organic matter return, and nutrient uptake, these cropping systems differ significantly. Spatial heterogeneity in soil fertility and nutrient status results from such variations in management techniques throughout time. In order to improve soil productivity, ensure sustainable agricultural development, and devise suitable site-specific nutrient management techniques, it is imperative to understand the current soil nutrient profile under these cropping systems.

Soil Nutrient Management for Sustainable Cropping Systems

The availability of vital macro and micronutrients needed for the best possible plant growth characterizes soil fertility. The availability of the three main macronutrients nitrogen (N), phosphorus (P), and potassium (K) determines crop performance. These nutrients are

frequently depleted from the soil as a result of continuous cropping, particularly when high-yielding varieties and rigorous management are used. Nutrient imbalances have grown common in areas such as Rajnagar, where fertilizer use is often uneven or based on general guidelines. For example, overuse of nitrogenous fertilizers frequently results in micronutrient, phosphorus, and sulfur deficiency symptoms which cause nutrient stress and lower production. Nutrient dynamics are impacted differently by different agricultural systems.

Due to the low residue return, the rice-wheat system, which predominates in most of North India, frequently causes phosphate depletion and a decline in soil organic carbon. However, unless offset by organic inputs or balanced fertilization, vegetable-based systems can exacerbate nutrient mining because of their increased nutrient intake and frequent tillage. Similar to this, depending on the kind of soil and how it is managed, oilseed-based systems like maize-mustard may exhibit varying nutrient demands and fertilization responses. As a result, assessing the nutritional status in each of these systems is crucial for making well-informed nutrient application decisions.

Soil health plays a vital role in ensuring agricultural sustainability in Bihar

With its fertile alluvial soils, Bihar has enormous potential for agricultural expansion. Reports from around the state, however, show that soil fertility is decreasing, especially in areas that are heavily farmed. According to statistics from the Soil Health Card system (Government of India, 2020), a significant percentage of Bihar's soils have low to medium amounts of phosphate and nitrogen. Additionally, micronutrient deficiencies like those in zinc and boron are become more prevalent, especially in regions that grow vegetables. These disparities endanger the quality of the environment in addition to limiting output and decreasing fertilizer use efficiency. Rajnagar Block and the Madhubani district are not an exception. Fertile soils and sufficient groundwater for irrigation underpin the district's varied farming systems. However, in certain places, nutritional deficits and decreased production have been caused by an over use of chemical fertilizers, inadequate management of organic matter, and knowledge of soil testing. Nutrient management is made more difficult by climate-induced uncertainty, such as erratic precipitation, floods, and extensive dry spells.

Site-Specific Nutrient Management (SSNM) is essential for addressing spatial variability in soil fertility and optimizing fertilizer application

Site-Specific Nutrient Management (SSNM) is an innovative approach that emphasizes applying nutrients according to the crop's real requirements and the soil's fertility level. In contrast to traditional blanket recommendations, it takes into account crop nutrient loss, residual nutrient status, and geographical variability in soil fertility. SSNM lowers input costs, improves fertilizer use efficiency, and reduces pollution in the environment. However, SSNM's effectiveness mostly depends on a precise evaluation of the soil's nutritional indicate under present cropping patterns.

Local farmers and extension agents will be able to develop customized nutrient management plans that meet the requirements of specific crops and systems by carrying out a soil fertility evaluation specific to the Rajnagar Block. Additionally, it will fund government programs that encourage integrated and climate-resilient farming practices, like the National Mission on Sustainable Agriculture (NMSA), Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), and the Soil Health Card program.

Various cropping systems are practiced in Rajnagar Block based on soil type, climate, and farmer preferences

Traditional and contemporary agricultural systems are mixed together in Rajnagar Block. The principal ones are as follows:

- **Rice-Wheat system:** a prevalent rotation based on cereals found in irrigated regions. In highland and less water-retentive soils, the maize-mustard system is a new rotation.
- **Vegetable–Vegetable system:** This is a year-round, intensive horticulture system that grows crops like okra, cauliflower, brinjal, and tomatoes.

The Fallow-Paddy strategy is a traditional method of growing a single kharif crop on marginal land or in fields that are flooded.

There are distinct nutrient dynamics in each of these systems. Vegetables, for example, have high nutritional needs, and if they are grown continuously without enough replacement, nutrient depletion may occur rapidly. Fallow-paddy systems, on the other hand, may have less nutrient mining, but because of monoculture, they run the danger of losing organic matter and exhibiting low biological activity.

Results and Discussion

Significant differences in the nutritional content of the four main cropping systems—rice-wheat, maize-mustard, vegetable-vegetable, and fallow-paddy—were found in the soil study. Due to intensive cultivation and regular organic inputs, vegetable-vegetable systems had the highest concentration of available nitrogen, which varied from 210 to 310 kg/ha. The amount of available phosphorus ranged from 12.3 to 28.5 kg/ha; rice-wheat systems showed moderate to low phosphorus content, indicating a requirement for replenishment, while vegetable-vegetable and maize-mustard systems showed comparatively higher values.

Fallow-Paddy and Vegetable-Vegetable systems maintained greater levels of potassium availability, which varied from 150 to 280 kg/ha. This could be because of potassium-rich inputs or decreased uptake during fallow seasons. Maize-Mustard systems exhibited the greatest levels of soil organic carbon (OC), which ranged from 0.48% to 0.72% and suggested improved organic matter management. The pH of the soil ranged from 6.4 to 7.2, indicating neutral to slightly acidic soil conditions that are perfect for the majority of crops.

In general, vegetable-vegetable systems had more nutrients, but they also showed indications of extensive extraction, which calls for frequent nutritional monitoring. Signs of phosphorus deficit and decreasing organic carbon were observed in rice-wheat fields, highlighting the significance of integrated nutrient management strategies in the area.

Conclusion

In Rajnagar Block, Madhubani, Bihar, the study showed significant variation in the soil nutrient condition among various agricultural systems. Higher levels of accessible nitrogen, phosphorus, and potassium were found in vegetable-vegetable systems, which were indicative of intensive input use but also of the risk of nutrient mining in the absence of balanced replenishment. Due to increased cereal cultivation without sufficient organic input, rice-wheat systems exhibited reduced organic matter and phosphate shortage, while maize-mustard systems retained comparatively high levels of organic carbon. The Fallow-Paddy system exhibited low biological activity because of monocropping, but moderate nutrient levels.

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