



## Evaluation of macronutrient status and nutrient index in soils of Barshitakli tehsil, Akola District

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**Abstract :** The study focused on evaluating the chemical and major nutrient status of soils in Barshitakli tehsil of Akola. A total of 100 soil samples were systematically collected using a geo-referencing system to represent the entire study area in terms of their chemical properties and surface nutrient status. All soils examined were slightly to moderately alkaline, with EC values within safe limits. The organic carbon content indicated a medium to moderately high level. The free CaCO<sub>3</sub> content ranged from moderately calcareous to calcareous. The average available major nutrient contents showed a low to medium level for nitrogen (103.48-290.30 kg ha<sup>-1</sup>), a low to medium level for P<sub>2</sub>O<sub>5</sub> (9.70-22.01 kg ha<sup>-1</sup>), and a medium to high level for K<sub>2</sub>O (263.25-544.54 kg ha<sup>-1</sup>). The available S varied from 8.20 to 20.65 mg kg<sup>-1</sup>. The correlation analysis revealed that nutrient availability decreases as pH increases. An increase in organic carbon was associated with higher levels of N, P, K, and S. The soil fertility index, calculated for major nutrients, indicated that, according to a six-tier system, nitrogen is in the low category, phosphorus and sulphur are in the moderate category, and potassium is in the very high category. These findings highlight the importance of customised soil management practices to optimise nutrient availability and improve soil fertility.

**Keywords:** *Macronutrients, Nutrient Index, Soil fertility, Barshitakli,*

### Introduction

Soil, a crucial natural resource, forms the foundation of agriculture by enabling plant growth and supporting crop production (Biswas & Das, 2014). With the growing global population, the demand for food and fibre has increased significantly, underscoring the need for effective soil management to meet these expanding requirements. Understanding soil properties and employing effective management practices are vital for sustainable agricultural productivity.

In Maharashtra, soils vary from poor to moderately fertile and exhibit significant differences in their genetic, morphological, physical, chemical, and

biological traits. This diversity requires the development of customised agronomic strategies to optimise productivity. Overexploitation of natural resources, including soil, has raised concerns about sustaining long-term fertility and ecological balance. Implementing effective soil management practices, such as those used in the Barshitakli block, is vital for increasing yields and securing food supply amid growing human impact on soil ecosystems (Zingore et al., 2011). Focusing on soil health and adopting sustainable methods are essential steps to protect this crucial resource for future generations.

As the primary source of nutrients for crops, soil supports plant growth and development in numerous ways (Singh *et al.*, 2018). Sustainable crop productivity depends on the careful management of soil nutrients

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(Singh & Mishra, 2021). A deeper understanding of soil fertility can help farmers boost yields while fostering sustainable farming practices (Prasad *et al.*, 2009). Key macro-nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), as well as soil pH and soil organic carbon (SOC), are essential for plant health. While soil contains significant nutrient reserves, many nutrients may not be in forms readily available for plant absorption (FAO, 2008).

Soil fertility and SOC levels are further diminished by factors such as erosion, topsoil depletion, and nutrient loss (Kuchanwar *et al.*, 2022). Continuous cropping, unbalanced fertiliser use, poor irrigation practices, and inadequate cultural methods exacerbate this issue (Ingle *et al.*, 2024). Additionally, increasing reliance on chemical fertilisers, coupled with shortened fallow periods, accelerates soil degradation (Karthikeyan *et al.*, 2014). Nutrient losses during plant development and harvesting underscore the need to preserve soil quality, which not only enhances agricultural productivity but also improves water and air quality and ensures the more efficient use of nutrients. (Dhotre *et al.*, 2019; Ingle *et al.*, 2024).

A soil test-based fertility management system offers a promising solution for enhancing agricultural productivity by identifying nutrient deficiencies and recommending targeted fertiliser applications (Kumar *et al.*, 2019). Soil testing provides critical insights into nutrient availability, guiding the optimal use of fertilisers based on the soil's current fertility status (Singh *et al.*, 2018). It was hypothesised that the Soils of Barshitakli Tahsil in Akola district exhibit spatial variability in macronutrient availability, and a systematic assessment, along with the status of the relevant nutrients and calculation of a nutrient index, can identify deficiencies or sufficiencies, thereby guiding region-specific nutrient management strategies for sustainable agricultural productivity. Therefore, an attempt has been made to understand the chemical properties and major nutrient status of Barshitakli tahsil in Akola district, Vidarbha region of Maharashtra with the following objectives: (1) To assess the status and

spatial variability of major soil macronutrients (N, P, K) in Barshitakli Tahsil through systematic sampling and laboratory analysis; (2) To compute the Nutrient Index (NI) for evaluating overall soil fertility and classifying soils into fertility categories; (3) To provide region-specific nutrient management recommendations for improving soil health and sustainable crop productivity.

## Materials and Methods

### Study Area

The field study was conducted in Barshitakli tehsil, located in Akola district, Maharashtra, within the Vidarbha region of the Amravati division. Located 19 km south of Akola, the district headquarters, Barshitakli, lies between latitudes 20°16'N and 21°17'N and longitudes 76°38'E to 77°38'E. Renowned for cultivating cotton, jowar, and wheat, this tehsil plays a significant role in regional agriculture. Akola district experiences a slight climatic variation across its north-south axis. While most of the district features a tropical savannah climate, the northern hilly areas, with elevations ranging from 950 to 1000 meters, exhibit a subtropical climate characterised by cold winters. Summers bring scorching heat, with temperatures reaching a maximum of 47.7°C, whereas winters are dry and chilly, sometimes dropping as low as 2°C. May, the hottest month in Maharashtra, records minimum temperatures of 11.9°C. Annual rainfall ranges from 740 mm to 860 mm, with a decade average (2009–2019) of 656.20 mm in Balapur and 742.80 mm in Murtizapur. The district's fertile soils, derived from volcanic trap rocks, dominate its "Payanghat" plain, covering 80% of the area. Black soils thrive along the left bank of the Purna River, enabling widespread cultivation in areas such as Balapur, Akola, and Barshitakli. Meanwhile, the Telhara and Akot tehsils, located along the right bank, host the fertile Purna Valley, renowned for its rich black soils, thriving agriculture, and mango groves. However, the landscape changes near the Gavilgarh and Ajanta hills, where soils become shallow, stony, and less productive. This area heavily relies on rainfall for agriculture, with a primary focus on *kharif* crops.

### Sampling Location

The GPS coordinates for soil sampling conducted in various villages within the Barshitakli region are presented in Table 1. Out of the 159 villages in the Barshitakli tehsil, 10 villages were selected for soil sampling using GPS gridding at 5 km intervals to ensure comprehensive coverage of the Barshitakli tehsil. Surface soil samples (0-20 cm depth) were collected

from 10 different villages, with 10 samples taken per village from farmers' fields, totalling 100 samples. These samples were gathered at 5 km grid intervals across the Barshitakli tehsil of Akola district. The collected samples were air dried, gently grinded and sieve through 2 mm and stored in properly labelled bag. The soil was analyzed for chemical properties, including pH, electrical conductivity (EC), organic carbon (OC), calcium carbonate ( $\text{CaCO}_3$ ), nitrogen (N), phosphorus (P), potassium (K), and sulphur (S).

**Table 1:** GPS location of selected villages for sampling

| Sr. No. | Name of village | Latitude  | Longitude |
|---------|-----------------|-----------|-----------|
| 1       | Kanheri Sarap   | 20.6385°N | 77.0545°E |
| 2       | Barshitakli     | 20.7039°N | 76.9971°E |
| 3       | Sukali          | 20.6448°N | 77.1801°E |
| 4       | Alanda          | 20.6378°N | 77.0442°E |
| 5       | Sarav           | 20.3400°N | 77.4000°E |
| 6       | Donad           | 20.5466°N | 77.6364°E |
| 7       | Sindkhed        | 20.5809°N | 76.9980°E |
| 8       | Dhaba           | 20.6972°N | 77.0717°E |
| 9       | Ujaleshwar      | 20.5220°N | 77.1427°E |
| 10      | Yeranda         | 20.6125°N | 77.1398°E |

### Soil Analysis

The soil pH was determined using a digital pH meter with glass electrodes and a 1:2.5 soil-to-water ratio, as described by Jackson (1973). Electrical conductivity (EC) was determined using a conductivity meter with a 1:2.5 soil-to-water suspension, as described by Jackson (1973). Organic carbon was determined using the Walkley and Black (1934) method, as described by Jackson (1973). Calcium carbonate was estimated using a rapid titration method with phenolphthalein indicator, as described by Piper (1966). Available nitrogen was determined using the alkaline permanganate method, as described by Subbiah and Asija (1956). The available phosphorus was determined using Olsen's reagent (0.5 M  $\text{NaHCO}_3$ , pH 8.5) as the extractant, measured by a spectrophotometer

(Jackson, 1973). Available potassium was extracted from the soil using a neutral normal ammonium acetate solution and estimated by flame photometry, as described by Jackson (1973). The available sulphur estimated turbidimetrically ( $\text{CaCl}_2$ ) was extracted using a spectrophotometer, as described by Piper (1966). The soil nutrient index was assessed using the Ramamurthy and Bajaj (1969) index rating formula.

## Results and Discussion

### Soil pH and Electrical Conductivity

Among all analysed soil samples, Sarav village had the lowest pH of 6.7, while soils from Kanheri Sarap and Ujaleshwar recorded the highest pH of 8.4 (Table 2). The soil pH in Barshitakli Tahsil ranged from 6.7 to 8.4, indicating slightly to moderately alkaline conditions,

with an average of 7.83 (Table 2). Similar findings were noted by Priyanka et al. (2018). The electrical conductivity (EC) of farmers' soils ranged from 0.121 to 0.389 dS m<sup>-1</sup>, all within the safe limit (<0.51 dS m<sup>-1</sup>), with an average of 0.222 dS m<sup>-1</sup> (Table 2). Notably,

Ujaleshwar soil showed the highest EC of 0.390 dS m<sup>-1</sup> and the lowest of 0.121 dS m<sup>-1</sup>, with an overall average of 0.223 dS m<sup>-1</sup>. Similar results were reported by Hadole et al. (2019).

**Table 2:** Range and mean of physico-chemical properties of soil.

| Village      | pH       |      | EC (dS m <sup>-1</sup> ) |       | CaCO <sub>3</sub> (%) |      | OC(g kg <sup>-1</sup> ) |      |
|--------------|----------|------|--------------------------|-------|-----------------------|------|-------------------------|------|
|              | Range    | Mean | Range                    | Mean  | Range                 | Mean | Range                   | Mean |
| KanheriSarap | 7.1-8.4  | 7.81 | 0.137-0.331              | 0.215 | 3.55-6.05             | 4.78 | 4.2-7.5                 | 6.52 |
| Barshitakli  | 7.3-8.2  | 7.76 | 0.156-0.273              | 0.207 | 3.90-5.65             | 4.82 | 4.5-7.2                 | 6.06 |
| Sindkhed     | 7.8-8.2  | 8.06 | 0.200-0.356              | 0.228 | 3.65-5.40             | 4.43 | 4.8-7.2                 | 6.29 |
| Sukali       | 7.6-8.2  | 7.88 | 0.145-0.295              | 0.228 | 3.95-6.10             | 4.90 | 4.4-7.2                 | 5.9  |
| Sarav        | 6.7-8.1  | 7.64 | 0.179-0.345              | 0.225 | 4.20-6.10             | 5.46 | 4.8-7.2                 | 6.68 |
| Dhaba        | 7.5-8.2  | 7.73 | 0.157-0.269              | 0.216 | 4.15-6.10             | 5.31 | 4.8-7.5                 | 6.05 |
| Ujaleshwar   | 7.7-8.2  | 8.05 | 0.122-0.390              | 0.211 | 3.80-6.70             | 5.16 | 3.9-7.3                 | 5.2  |
| Alanda       | 7.4-8.3  | 7.91 | 0.179-0.388              | 0.245 | 3.95-6.05             | 4.82 | 4.3-7.2                 | 5.73 |
| Donad        | 7.4-8.2  | 7.80 | 0.174-0.319              | 0.219 | 3.95-5.80             | 4.99 | 4.4-7.3                 | 6.21 |
| Yeranda      | 7.1- 8.3 | 7.64 | 0.123-0.389              | 0.222 | 4.25-5.85             | 4.81 | 4.2-7.5                 | 6.01 |

#### Organic Carbon and Calcium Carbonate

The organic carbon content in the soil ranged from 3.9 to 7.5 g kg<sup>-1</sup>, with a mean value of 6.05 g kg<sup>-1</sup> (Table 2). The lowest organic carbon level was recorded in Ujaleshwar village (3.9 g kg<sup>-1</sup>), while the highest was observed in Kanheri Sarap, Donad, and Yeranda villages (7.5 g kg<sup>-1</sup>). Overall, the organic carbon levels in the soils of Barshitakli tehsil varied from medium to moderately high, aligning with findings reported by Raut et al. (2017) and Ingle et al. (2024). The presence of calcium carbonate (CaCO<sub>3</sub>) indicates the soil's calcareous nature. Analysis showed that CaCO<sub>3</sub> content ranged from 3.55% to 6.6%, with an average of 4.95% (Table 2). The highest calcium carbonate content (6.7%) was found in Ujaleshwar village, while the lowest (3.55%) was recorded in Kanheri Sarap and Yeranda villages. These results suggest that the soils are moderately calcareous to calcareous, consistent with the findings of (Katkar et al., 2013; Ingle et al., 2019; Kuchanwar et al., 2022)

#### Available Macronutrient status of soil

##### Available Nitrogen

The available nitrogen content in the soils of Barshitakli tehsil ranged from 103.48 to 290.30 kg ha<sup>-1</sup>, with an average of 181.46 kg ha<sup>-1</sup> (Table 3). The highest nitrogen level was recorded in Yeranda village (290.30 kg ha<sup>-1</sup>), while the lowest was observed in Sukali village (103.48 kg ha<sup>-1</sup>). Based on these results, the soils were classified as having poor to low to medium nitrogen availability. Out of the 100 soil samples analysed, 12 samples fell into the very low category, 87 samples were classified as low (<140 kg ha<sup>-1</sup>), and only one sample was categorised as medium (Table 4). Across the tehsil, the available nitrogen content was predominantly very low to low. These findings are consistent with those reported by (Deshmukh *et al.*, 2007; Ingle et al., 2019; Kuchanwar *et al.*, 2021)

##### Available Phosphorus

The available phosphorus content in the soils of Barshitakli tehsil ranged from 9.70 to 22.01 kg ha<sup>-1</sup>, with

**Table 3:** Range and means of Macronutrient content in soils of Barshitakli tahsil.

| Village      | N (kg ha <sup>-1</sup> ) |        | P (kg ha <sup>-1</sup> ) |       | K (kg ha <sup>-1</sup> ) |        | S (kg ha <sup>-1</sup> ) |       |
|--------------|--------------------------|--------|--------------------------|-------|--------------------------|--------|--------------------------|-------|
|              | Range                    | Mean   | Range                    | Mean  | Range                    | Mean   | Range                    | Mean  |
| KanheriSarap | 154.65-278.23            | 213.66 | 10.10-21.62              | 15.85 | 313.21-544.54            | 399.09 | 9.48-20.65               | 13.23 |
| Barshitakli  | 125.78-250.53            | 177.21 | 11.43-19.50              | 14.15 | 311.05-406.67            | 363.64 | 9.05-16.78               | 12.36 |
| Sindkhed     | 144.25-278.23            | 210.86 | 10.63-20.56              | 16.16 | 263.25-430.57            | 362.91 | 10.34-19.79              | 13.70 |
| Sukali       | 103.48-237.98            | 159.24 | 12.22-17.65              | 14.38 | 287.15-454.48            | 373.2  | 8.20-19.36               | 12.50 |
| Sarav        | 110.23-247.15            | 180.04 | 12.35-20.60              | 14.70 | 287.15-478.38            | 406.67 | 8.20-19.36               | 14.91 |
| Dhaba        | 106.69-244.61            | 167.08 | 9.70-20.02               | 15.51 | 311.05-526.19            | 413.84 | 8.63-16.78               | 13.22 |
| Ujaleshwar   | 110.26-222.65            | 157.67 | 9.84-21.22               | 16.72 | 311.05-4539.05           | 416.23 | 10.77-16.79              | 12.66 |
| Alanda       | 134.85-247.23            | 176.22 | 10.23-22.01              | 15.92 | 311.05-502.28            | 416.23 | 10.77-16.78              | 13.52 |
| Donad        | 116.03-260.35            | 193.81 | 11.38-20.55              | 15.97 | 311.05-502.28            | 423.4  | 8.20-20.65               | 15.50 |
| Yeranda      | 109.76-290.23            | 182.08 | 10.22-22.01              | 16.80 | 268.00-454.47            | 356.44 | 9.92-20.65               | 15.37 |

an average value of 15.61 kg ha<sup>-1</sup> (Table 3). Approximately 37% of the soil samples were classified as having low fertility, while 61% fell into the medium fertility category based on available phosphorus levels. The nutrient index value for phosphorus indicated a low to moderate fertility class for Barshitakli tahsil. The data revealed that the lowest phosphorus content (9.7 kg ha<sup>-1</sup>) was observed in Dhaba village, whereas the highest phosphorus levels (22.01 kg ha<sup>-1</sup>) were recorded in Alanda and Yeranda villages. Of the 100 samples analysed, 37 were categorised as low in available phosphorus (<14 kg ha<sup>-1</sup>), 61 were classified as medium (14-22 kg ha<sup>-1</sup>), and two samples exhibited high phosphorus content. The soils were divided into six categories (Table 4), with phosphorus content ranging from low to moderately high. Similar findings were reported by (Choudhariat *et al.*, 2018; Ingle *et al.*, 2018; Dhotare *et al.*, 2019; Kuchanware *et al.*, 2022)

#### Available Potassium

The available potassium content in the soils of Barshitakli tahsil ranged from 263.25 to 544.54 kg ha<sup>-1</sup>,

with an average of 394.92 kg ha<sup>-1</sup> (Table 3). The highest potassium level was observed in Kanheri Sarap village (544.54 kg ha<sup>-1</sup>), while the lowest was recorded in Sindkhed village (263.25 kg ha<sup>-1</sup>). None of the soil samples analysed fell into the low-fertility category for potassium. Of the 100 samples, six were classified as having high fertility, and 94 were categorised as having very high fertility due to their potassium content. This indicates that the available potassium content varied from high to very high levels (Table 4). These findings are consistent with those reported by Ingle *et al.* (2018) and Dhotare *et al.* (2019).

#### Available Sulphur

The available sulphur content in the soils of Barshitakli tahsil ranged from 8.20 to 20.65 kg ha<sup>-1</sup>, with an average value of 13.71 kg ha<sup>-1</sup> (Table 3). The lowest sulphur levels (8.20 mg kg<sup>-1</sup>) were recorded in Sukali, Sarav, and Donad villages, while the highest (20.65 mg kg<sup>-1</sup>) was observed in Donad village. Out of all the soil samples analysed, 13 were classified as low fertility, 56 as medium fertility, 27 as moderately high, and four as

high fertility for sulphur content. Overall, the available sulphur levels across the tehsil varied from low to moderately high categories (Table 4). These findings align with those reported by Medhe et al. (2012) and Kuchanwar et al. (2022).

#### *Relationship between Soil Chemical Properties and Available Macronutrients*

Correlation analysis is given in Table 5. The available nitrogen shows a positive correlation with organic carbon ( $r = 0.651^{**}$ ) and a negative correlation with pH ( $r = -0.013$ ), as well as a negative, significant

**Table 4:** N,P, K and S classes of soils of Barshitakli tehsil.

| Class             | Available N<br>(kg ha <sup>-1</sup> ) | No. of Sample | Available P<br>(kg ha <sup>-1</sup> ) | No. of Sample | Available K<br>(kg ha <sup>-1</sup> ) | No. of Sample | Available S<br>(kg ha <sup>-1</sup> ) | No. of Sample |
|-------------------|---------------------------------------|---------------|---------------------------------------|---------------|---------------------------------------|---------------|---------------------------------------|---------------|
| I (Very low)      | <140                                  | 12            | <7                                    | 00            | <100                                  | 00            | <5                                    | 0             |
| II(Low)           | 141-280                               | 87            | 8-14                                  | 37            | 101-150                               | 00            | 5-10                                  | 13            |
| III(Medium)       | 281-420                               | 01            | 15-21                                 | 61            | 151-200                               | 00            | 0-15                                  | 56            |
| IV(Moderate High) | 421-560                               | 00            | 22-28                                 | 02            | 201-250                               | 00            | 5-20                                  | 27            |
| V(High)           | 561-700                               | 00            | 29-35                                 | 00            | 251-300                               | 06            | 20-25                                 | 04            |
| VI(Very High)     | >700                                  | 00            | >35                                   | 00            | >300                                  | 94            | >25                                   | 00            |

correlation with calcium carbonate ( $r = -0.239^{*}$ ). It shows that the available nitrogen (N) increased significantly with an increase in organic carbon. A similar relationship between available N and pH was reported by Meena et al. (2006). The available phosphorus shows a negative correlation with pH ( $r = -0.379^{**}$ ) and EC ( $r = -0.371^{**}$ ). Similar results were found by Bhagat (2012). The available K showed significant correlation with pH ( $r = 0.119$ ), EC ( $r = 0.022$ ), OC ( $r = 0.036$ ) and CaCO<sub>3</sub> ( $r = 0.232^{*}$ ) was

observed. The availability of sulphur was significant and negatively correlated with the pH ( $r = -0.287^{**}$ ) of the soil under various cropping sequences. A non-significant correlation was observed between sulphur and EC ( $r = -0.199$ ), whereas a significant and positive correlation was observed with OC ( $r = 0.219^{*}$ ). The soil pH of the surface layer had a significant and negative correlation with available sulfur (S) ( $r = -0.395^{**}$ ) as reported by Raut et al. (2017).

**Table 5:** Relationship between soil chemical properties with available major nutrients

| Parameters | pH       | EC       | OC      | CaCO <sub>3</sub> |
|------------|----------|----------|---------|-------------------|
| N          | -0.013   | -0.038   | 0.651** | -0.239*           |
| P          | -0.379** | -0.371** | 0.092   | -0.112            |
| K          | 0.119    | 0.022    | 0.036   | 0.232*            |
| S          | -0.287** | -0.199*  | 0.219*  | -0.138            |

\*Significant at 5 % level of significance ( $r=0.195$ )

\*\*Significant at 1 % level of significance ( $r=0.254$ )

### Nutrient Index of Macronutrient

The study assessed soil fertility status to promote the efficient and balanced use of fertilisers. Soils were classified into various categories based on their nutrient content using a six-tier classification system. According to the six-tier system presented in Table 6, the fertility index for organic carbon was moderate at 1.75%. The fertility index for nitrogen (N)

was low at 0.95 kg ha<sup>-1</sup>, while phosphorus (P) and potassium (K) displayed moderate (1.33 kg ha<sup>-1</sup>) and very high (2.97 kg ha<sup>-1</sup>) fertility indexes, respectively. The fertility index for sulphur (S) was also rated as moderate at 1.61 mg kg<sup>-1</sup>. These findings align with those reported by Dhotare et al. (2019).

**Table 6: Soil Nutrient Index of Barshitakli Tahsil**

| Nutrient                                    | Fertility Index | Category  |
|---------------------------------------------|-----------------|-----------|
| Organic Carbon (g kg <sup>-1</sup> )        | 0.75            | Moderate  |
| Available Nitrogen (kg ha <sup>-1</sup> )   | 0.95            | Low       |
| Available Phosphorous(kg ha <sup>-1</sup> ) | 1.33            | Moderate  |
| Available Potassium(kg ha <sup>-1</sup> )   | 2.97            | Very High |
| Available Sulphur(kg ha <sup>-1</sup> )     | 1.61            | Moderate  |

### Conclusions

It can be concluded from the study that the soils in Barshitakli tahsil of Akola district, Maharashtra, were slightly to moderately alkaline in soil reaction (pH), and the soluble salt content (EC) falls within the safe limit. The organic carbon level was medium to high, and the soils were moderately to highly calcareous. Soils were low to medium in available N and P, low to high in available S, and medium to high in available K. Soil pH and EC showed a negative correlation with available N, P, and S. However, there is a positive, significant correlation among organic carbon and available N, K, and S, indicating the soil's potential for growth and productivity. This study provides a comprehensive assessment of the macronutrient status and nutrient indices in the soils of Barshitakli Tahsil, Akola District. The findings reveal significant variations in nutrient levels across different sites, highlighting zones of nutrient adequacy and deficiency. These insights are crucial for devising targeted soil fertility management strategies to enhance agricultural productivity and

sustainability in the region. Future research could focus on the influence of cropping practices and environmental factors on nutrient dynamics, thereby further supporting the development of region-specific recommendations for optimising soil health and crop productivity.

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