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# Comparative Study of Irrigated Farmlands of Argungu: Addressing Food Security Challenges through Enhanced Farming Yield

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## Abstract

The physicochemical characteristics of soil in irrigated farmlands play a critical role in influencing soil fertility, crop health, and sustainable agricultural practices. This study evaluated the soil properties of four irrigated farmlands in Argungu over three months (March to May), the following variables were evaluated using standard methods; pH, electrical conductivity (EC), organic carbon (OC), calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na). The findings revealed that the pH ranged from mildly acidic to neutral, with Farmland-1 showing the most fluctuations. EC values suggested moderate salinity levels, with Farmland-2 exhibiting the highest EC in May. Organic carbon levels varied, particularly in Farmland-1, while Farmlands-3 and 4 maintained stable OC levels. Calcium and magnesium levels were generally consistent across the farmlands, with calcium slightly higher, supporting soil structure and crop growth. Potassium levels were stable, with Farmland-1 having slightly higher values. Sodium levels were low across all farmlands, indicating effective management. Conclusively, the study suggests that different farmlands may require tailored soil management practices to support sustainable agriculture, including potential magnesium supplementation for Farmland-2. Also, combination of appropriate irrigation practices and soil management strategies are recommended for a significant influence in agricultural productivity.

**Keywords**: Argungun, Farmlands, Irrigation, Nutrient, Soil fertility

## I. Introduction

Irrigation plays a pivotal role in agricultural productivity, particularly in regions facing erratic rainfall patterns or limited access to water resources. In the context of addressing food security challenges, understanding and optimizing irrigated soil conditions is critical for enhancing farming yield and ensuring sustainable agricultural practices (FAO,2017). Irrigated agriculture plays a crucial role in meeting the growing demand for food in a world facing challenges such as population growth, climate change, and land degradation. Enhancing soil fertility and productivity in irrigated farmlands is essential for ensuring food security and sustainable agricultural development (Brevik *et al.*, 2019). Several studies have highlighted the importance of soil fertility and management practices in irrigated agriculture (Smith *et al.*, 2018; Lal, 2015). Nutrient deficiencies, soil acidity or alkalinity, and poor soil structure can significantly impact crop growth and yield (Brevik *et al.*, 2019; Mishra *et al.*, 2020). Effective irrigation management and soil conservation techniques are essential for maintaining soil health and maximizing agricultural output (FAO, 2017; Sharma *et al.*, 2021). Argungu is situated in the northwestern part of Nigeria, is renowned for its rich agricultural heritage, with farming serving as the primary livelihood for a significant portion of the population. However, like many agricultural regions globally, Argungu faces challenges related to; changes in irrigation productions, soil degradation, and climate variability, which pose threats to food security and livelihoods.

Inadequate irrigation for agricultural purposes is caused by a variety of factors, including limited access to water resources as a result of unpredictable rainfall patterns, ineffective water management techniques, and competing water demands from other sectors (Adamu, 2018). On the other hand, inadequate irrigation infrastructure, like reservoirs, canals, and dams, results in ineffective water distribution and use, which lowers agricultural output (Ogunkunle *et al.*, 2019). Furthermore, the application of contemporary irrigation technologies and infrastructure modifications necessary for sustainable irrigation practices is hampered by the restricted financial resources allotted to irrigation development projects (Adeola *et al.*, 2020). Furthermore, inadequate water use efficiency and crop yields are caused by farmers' ignorance of and lack of access to contemporary irrigation techniques, tools, and agronomic practices (Abdul-Aziz *et al.*, 2017). Moreover, poor irrigation techniques lead to waterlogging, salinization, and soil erosion, all of which worsen soil fertility (Nwachukwu *et al.*, 2018). This study was aimed to conduct a comparative study of irrigated farmlands of Argungu in order to address issues of food security challenges through enhanced farming yield.

## II. Methodology

Samples were collected from four selected farmlands; soil samples were analyzed using standard methods. Soil pH was measured using the glass electrode method, where 20 g of soil sample was mixed with 20 ml of distilled water in a 100 ml beaker (Bouyoucos, 2003). Organic carbon content was determined via the Walkley and Black (1934) method, involving treatment with excess potassium dichromate and sulfuric acid, followed by titration. Sodium and potassium concentrations were measured using the flame photometer method, calibrated with standard solutions ranging from 0-100 ppm (Bouyoucos, 2003). Calcium and magnesium were determined by the EDTA titration method, with ethylene diamine tetraacetic acid (EDTA) used as a chelating agent. Nitrogen concentration, in the form of nitrate and nitrite, was analyzed spectrophotometrically using a smart spectrophotometer. Phosphorus concentration was determined using a spectrophotometer at a 600 mµ wavelength, following a chemical extraction process and Bray method (Bouyoucos, 2003). Farmers' perceptions of variations in soil fertility, production, irrigation output, and the factors influencing these variations were assessed using a standardized questionnaire.

### Statistical analysis

Data generated will be analyzed statistically using the Graphpad prism version 6.5. All results values will be expressed as mean ± standard deviation (SD). The data will be analyzed using one-way analysis of variance (ANOVA), $P<0.05$ will be considered as statistically significant.

## III. Results

The results obtained from the four irrigated farmlands in Argungu revealed several key soil characteristics, measured monthly (March, April, and May), including pH, electrical conductivity (EC), organic carbon (OC), calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na). Below is an extensive comparison of these soil parameters across the farmlands, assessing seasonal trends and inter-farmland differences. The pH levels across all farmlands range from mildly acidic to neutral, with values between 6.57 and 7.03. Farmland 1 shows the highest pH fluctuation, from 6.60 in March to 7.03 in May, indicating a shift towards a neutral state over the months. Farmland 2 maintains a more stable, slightly acidic pH, ranging from 6.57 to 6.80. Both Farmlands 3 and 4 also have a slightly fluctuating pH but remain relatively close to neutral, with values from 6.73 to 7.00 in March and May, respectively. Generally, Farmland 1 shows the most significant increase in pH over time, suggesting higher buffering capacity or variation in soil amendments (Table 1).

The EC values, which indicate soil salinity levels, generally range between 101.3 µS/cm and 113 µS/cm across all farmlands. Farmland 2 shows the highest peak in May (113.0 µS/cm), while Farmland 1 shows the lowest reading in April (101.3 µS/cm). These variations imply that Farmland 2 may be experiencing a buildup of salts towards the growing season's peak. Overall, Farmlands 3 and 4 have more stable EC levels, hovering around 109-112 µS/cm. The moderate EC levels across all fields suggest a well-managed irrigation system, with no excessive salinity that could inhibit crop growth.

Organic carbon levels are crucial for soil fertility, affecting microbial activity and nutrient availability. Farmland 1 shows the highest variability in OC, with values as low as 3.10 g/kg in April and as high as 6.73 g/kg in May. Farmlands 3 and 4 maintain more consistent OC levels, staying close to 6 g/kg throughout the period, which implies stable organic matter content. Farmland 2, with OC ranging from 5.17 to 6.10 g/kg, presents an intermediate consistency compared to the other fields. Farmland 1's fluctuating OC levels may indicate differences in organic inputs or residue management practices.

Calcium levels across the farmlands show relatively low variance, ranging from 1.13 g/kg to 1.33 g/kg. Farmland 1 has the highest Ca content (1.33 g/kg in May), while Farmland 4 remains on the lower end of the range (1.13 g/kg in April). The consistency in Ca levels suggests that all farmlands have a similar source of calcium, possibly due to uniform irrigation water or lime application. These levels are beneficial for improving soil structure and aiding plant growth. Magnesium levels show slightly higher variance compared to Ca, with values ranging from 0.92 g/kg in Farmland 2 (May) to 1.31 g/kg in Farmland 1 (April). Farmland 1 generally has higher Mg values, suggesting it may receive additional Mg inputs or has soil with naturally higher Mg content. Farmland 2 shows a noticeable drop in Mg in May, which could impact crop growth if this decline continues, as Mg is essential for chlorophyll production.

Potassium levels across the farmlands are generally stable, ranging from 0.29 to 0.37 g/kg. Farmland 1 maintains the highest K levels (0.37 g/kg across April and May), suggesting this soil might be better suited for crops with high K demands. Farmland 4, with K values consistently around 0.30-0.31 g/kg, has comparatively lower K levels, which may require supplemental K inputs for optimal crop production. The consistent K values across all farmlands indicate minimal K leaching or depletion, likely due to good soil retention capacity.

Sodium levels vary slightly across the farmlands, with values ranging from 0.62 to 0.77 g/kg. Farmland 3 shows the highest Na levels in March (0.77 g/kg), while Farmland 2 shows a notable decline in April and May. Elevated Na levels, if not managed, could lead to soil compaction and reduced water infiltration. However, the range observed is low enough to avoid significant sodicity issues, suggesting that the irrigation system helps manage Na accumulation effectively.

Farmland 1shows the most significant variability in pH and OC, with slightly higher Ca and K levels. It appears well-buffered with moderate EC levels, making it potentially well-suited for crops requiring consistent nutrient availability. Farmland 2 tend to maintains steady but slightly lower pH levels and lower Mg by May, which may affect crop health if Mg deficiency persists. Higher EC in May may suggest salt accumulation over time. While Farmland 3 demonstrates stable Na and K levels with relatively high OC, suggesting good organic matter content. This farmland’s overall stability in parameters may benefit crops requiring consistent soil conditions. Farmland 4 was generally stable soil parameters with slightly lower K and stable Ca and Mg levels, indicating well-balanced nutrients. Low variation in pH and EC makes it suitable for crops sensitive to salinity and pH fluctuations (Table1).

The monthly variations of selected physicochemical variables organic carbon (OC), calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) in the soils of four irrigated farmlands in Argungu, measured from March to May. Organic Carbon (OC) shows the highest levels among the parameters across all farmlands and months, suggesting significant organic matter presence in the irrigated soils. Calcium (Ca) and magnesium (Mg) levels are relatively consistent across all farmlands, with Ca being higher than Mg in each case. Potassium (K) and sodium (Na) exhibit lower levels compared to OC, Ca, and Mg but remain fairly stable across the months in all irrigated farmlands. The trends in each variable are similar across Farmlands indicating consistent soil management or similar environmental conditions affecting all farmlands (Figure 1). Therefore, the figure illustrated monthly stability in soil nutrients, with OC as the dominant component, indicating potentially good soil fertility across the studied irrigated farmlands.

**Table 1: Level of Physicochemical Variables of Argungu Irrigated Farmlands**

| Farmlands | Month | pH | EC (μs/cm) | OC (g/Kg) | Ca (g/Kg) | Mg (g/Kg) | K (g/Kg) | Na (g/Kg) |
|---|---|---|---|---|---|---|---|---|
| 1 | March | 6.60±0.10 | 109.7±0.66 | 6.13±0.22 | 1.28±0.05 | 1.23±0.03 | 0.36±0.02 | 0.75±0.01 |
| | April | 7.00±0.00 | 101.3±0.33 | 6.31±0.15 | 1.14±0.15 | 1.31±0.01 | 0.37±0.00 | 0.64±0.01 |
| | May | 7.03±0.23 | 110.3±1.20 | 6.73±0.17 | 1.33±0.02 | 1.27±0.04 | 0.37±0.02 | 0.72±0.04 |
| 2 | March | 6.57±0.07 | 110.0±1.53 | 6.10±0.20 | 1.21±0.10 | 1.23±0.02 | 0.35±0.03 | 0.73±0.02 |
| | April | 6.80±0.12 | 110.3±1.33 | 5.17±0.07 | 1.19±0.10 | 1.18±0.10 | 0.32±0.02 | 0.62±0.01 |
| | May | 6.70±0.12 | 113.0±0.56 | 5.83±0.22 | 1.15±0.09 | 0.92±0.28 | 0.32±0.02 | 0.71±0.01 |
| 3 | March | 6.73±0.09 | 109.0±1.73 | 6.47±0.12 | 1.25±0.09 | 1.23±0.02 | 0.35±0.02 | 0.77±0.01 |
| | April | 7.00±0.06 | 111.0±2.00 | 6.03±0.26 | 1.16±0.09 | 1.23±0.01 | 0.33±0.02 | 0.71±0.01 |
| | May | 6.87±0.12 | 111.0±0.58 | 6.06±0.27 | 1.16±0.09 | 1.11±0.00 | 0.29±0.00 | 0.71±0.01 |
| 4 | March | 7.00±0.06 | 112.0±0.58 | 6.10±0.06 | 1.17±0.04 | 1.11±0.00 | 0.30±0.01 | 0.72±0.00 |
| | April | 6.97±0.03 | 111.3±0.33 | 6.13±0.03 | 1.13±0.08 | 1.12±0.06 | 0.31±0.00 | 0.72±0.00 |
| | May | 6.97±0.03 | 110.7±0.67 | 6.03±0.09 | 1.15±0.06 | 1.13±0.06 | 0.31±0.01 | 0.72±0.01 |

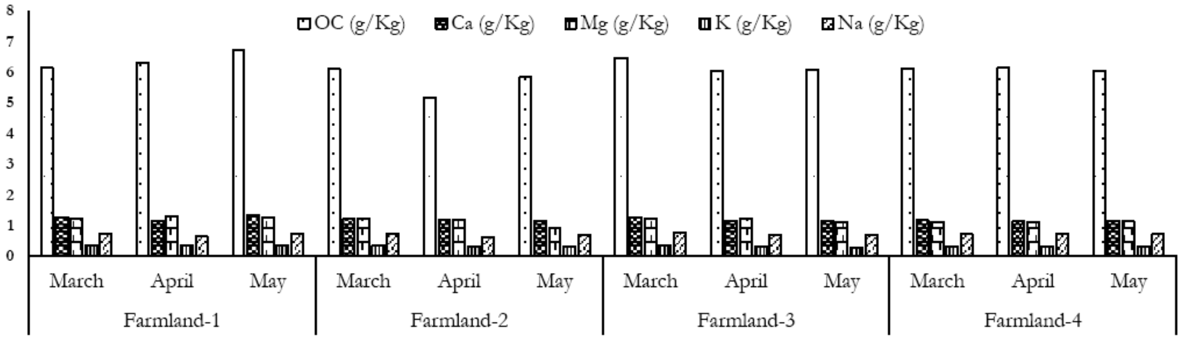

**Figure 1: Monthly Variations of Some Selected Physicochemical Variables of Irrigated Farmlands Soils of Argungu**

The evaluation of irrigation practices across four farmlands in Argungu reveals variations in farm size, soil fertility, agricultural production, and irrigation output. Farmers across all four farmlands are experienced, with ages ranging from 19 to 60 years and farming experience spanning 21 to 60 years. Farmland-1 has the largest farm size and the highest soil fertility, while Farmland-2 has the smallest farm size and lower soil fertility. In terms of agricultural production, Farmland-4 experienced the most significant increase in production, while Farmland-2 showed no change. Farmland-1 showed slight improvements, and Farmland-3 saw moderate increases in production. The irrigation output also varied, with Farmland-1 achieving excellent results, while Farmland-2's irrigation was fair to good. Both Farmland-3 and Farmland-4 showed good output. The strategies used by the farmers included a mix of manure and fertilizer for Farmland-1 and Farmland-3, manure alone for Farmland-2, and fertilizer alone for Farmland-4. These suggest that the combination of appropriate irrigation practices and soil management strategies significantly influences agricultural productivity, with Farmland-4's substantial increase in production highlighting the effectiveness of these practices (Table 2).

**Table 2: Evaluation of Farmers Irrigation Practices of Argungu Irrigated Farmlands**

| Variable | Farmland-1 | Farmland-2 | Farmland-3 | Farmland-4 |
|---|---|---|---|---|
| Age | 21-60 | 22-55 | 19-47 | 22-50 |
| Farm Size (Hectares) | 2-10 | 2-7 | 3-10 | 1-5 |
| Yrs of Farming experience | 21-60 | 21-60 | 21-60 | 21-60 |
| Soil Ferlity | High | Low-Moderate | Moderate | Moderate -High |
| Agricultural Production | No change - Slightly increased | No change | Increased | Significantly increased |
| Irrigation Output | Excellent | Fair- Good | Good | Good |
| Strategies | Manure and Fertilizer | Manure | Manure and Fertilizer | Fertilizer |

## IV. Discussion

The results from the four irrigated farmlands in Argungu provide insight into the physicochemical characteristics of the soils, with important implications for crop health, soil fertility, and sustainable agricultural practices. The monthly measurements of pH, electrical conductivity (EC), organic carbon (OC), calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) from March to May reveal subtle but significant variations, each indicative of specific soil conditions and trends. This discussion compares these findings to related research to contextualize the results.

The pH levels across the farmlands ranged from mildly acidic to neutral, with values between 6.57 and 7.03. Farmland 1, which exhibited the highest fluctuation (from 6.60 in March to 7.03 in May), demonstrates a transition towards neutrality over time. This trend could reflect soil buffering capacity or the application of lime, which is known to gradually raise pH levels in acidic soils (Huang et al., 2018). In contrast, Farmland 2 maintained a relatively stable, mildly acidic pH, from 6.57 to 6.80, potentially due to consistent soil management practices. Both Farmlands 3 and 4 also demonstrated minor pH fluctuations, suggesting good pH stability, which is often essential for crops sensitive to acidity shifts. According to Ahmad et al. (2019), pH stability in irrigated soils is crucial for nutrient availability and uptake, as extreme pH values can lead to nutrient imbalances or deficiencies.

EC values ranged between 101.3 µS/cm and 113.0 µS/cm, indicating moderate salinity levels across all farmlands. Farmland 2 recorded the highest EC in May (113.0 µS/cm), suggesting a gradual accumulation of salts over the growing season, which could be attributed to irrigation water quality or seasonal evaporation patterns (Ayres & Westcot, 1985). Farmland 1 showed the lowest EC in April (101.3 µS/cm), likely indicating a brief period of lower salt accumulation or higher rainfall, which can dilute salts (Saha et al., 2021). The stable EC levels in Farmlands 3 and 4 (hovering around 109-112 µS/cm) imply well-managed irrigation practices that prevent excessive salt buildup, which aligns with findings by Singh et al. (2020), who emphasized that controlled EC levels are critical for crop yield and soil health in irrigated agricultural systems. Organic carbon (OC) levels are essential for soil fertility, influencing microbial activity, soil structure, and nutrient availability. Farmland 1 showed significant OC variability, with levels fluctuating from 3.10 g/kg in April to 6.73 g/kg in May. This wide range might reflect differences in organic inputs or crop residue management, as suggested by Lal (2018), who found that organic amendments, such as compost or crop residues, can lead to OC fluctuations based on application timing and decomposition rates. Farmlands 3 and 4, with OC levels consistently close to 6 g/kg, indicate stable organic matter content, which is conducive to maintaining soil health and fertility. Consistent OC levels, as observed in Farmland-2 (5.17 to 6.10 g/kg), further highlight steady organic matter management. Research by Franzluebbers (2020) suggests that stable OC content is linked to improved soil aggregation and water-holding capacity, which benefit crops by providing a steady nutrient supply.

Calcium and magnesium levels showed relatively low variance, with Ca ranging from 1.13 to 1.33 g/kg and Mg from 0.92 to 1.31 g/kg across all farmlands. Farmland 1 recorded the highest Ca (1.33 g/kg in May), potentially due to liming practices or natural soil composition, as lime increases Ca content over time (Fageria, 2009). Farmland-4, with a slightly lower Ca range (1.13 g/kg in April), showed consistency, possibly due to balanced nutrient applications or inherent soil properties. Calcium is essential for cell wall structure and root development, while Mg is crucial for chlorophyll production, making both nutrients vital for crop growth (Marschner, 2012). The relatively stable Ca and Mg levels across all farmlands reflect uniform irrigation water quality or similar soil management practices, aligning with results by Su *et al.* (2019), who noted the importance of Ca and Mg stability in irrigated systems for sustained crop productivity. Potassium levels were generally stable, ranging from 0.29 to

0.37 g/kg, with Farmland 1 showing slightly higher K levels (0.37 g/kg in April and May). This suggests that Farmland 1 may be more suited to crops with high K demands, such as tuber crops, which benefit from higher potassium availability (Cakmak, 2010). Farmland 4, with consistently lower K levels (around 0.30-0.31 g/kg), might require supplemental K inputs to optimize crop production. Stable K values across farmlands imply minimal leaching, which is advantageous, as K is vital for photosynthesis and water regulation in plants (Mengel & Kirkby, 2001).

Sodium levels were slightly variable, ranging from 0.62 to 0.77 g/kg. Farmland 3 had the highest Na in March (0.77 g/kg), while Farmland 2 exhibited a decline in Na levels in April and May. Elevated Na levels, if not managed, can lead to soil compaction and reduced water infiltration (Sumner, 2012). However, the observed Na range is low enough to avoid significant sodicity issues, indicating that the irrigation system effectively manages Na accumulation. Stable Na levels, as highlighted by Zhang *et al.* (2020), help maintain soil structure and prevent salinity-related stress on crops.

Among the farmlands, Farmland 1 showed the most variability in pH, OC, and nutrient levels, possibly reflecting dynamic soil management practices or a more diverse crop rotation system. This variability may enhance the adaptability of Farmland 1 to a wide range of crops, provided that nutrient inputs are balanced over time. Farmland 2, with lower pH and Mg by May, may require adjustments to Mg inputs to prevent potential deficiencies, as Mg is essential for photosynthesis (Epstein & Bloom, 2005). Farmland 3, with stable OC, Na, and K levels, appears conducive to crops needing consistent nutrient availability. Farmland 4, with relatively stable soil parameters and slightly lower K, seems well-suited for crops sensitive to salinity and pH fluctuations, as these stable conditions reduce the risk of nutrient imbalances.

The consistency in Ca, Mg, and EC across all farmlands highlights effective irrigation and nutrient management practices that minimize excessive fluctuations. The monthly stability in OC across Farmlands 3 and 4 suggests a sustainable approach to maintaining soil organic matter. These findings align with previous studies that emphasize the importance of nutrient stability in promoting long-term soil fertility and crop health in irrigated agricultural systems (Nielsen *et al.*, 2021). Future studies could further explore how different organic amendments influence the nutrient dynamics observed in these farmlands, as organic inputs play a critical role in enhancing soil structure, fertility, and resilience to environmental changes (Gattinger *et al*., 2012).

The evaluation of irrigation practices across the four farmlands in Argungu reveals that factors such as soil fertility, irrigation output, and farm management strategies play crucial roles in agricultural productivity. Farmland-1, which has the largest farm size and the highest soil fertility, showed excellent irrigation output and a slight increase in production. This result aligns with findings from other studies, such as that of Olayide *et al.* (2017), who observed that higher soil fertility and effective irrigation practices contribute significantly to increased crop yields. Similarly, Adejuwon *et al.* (2015) found that farms with better soil conditions and well-managed irrigation systems tend to have improved agricultural productivity. However, Farmland-2, with lower soil fertility and fair to good irrigation output, exhibited no change in agricultural production. This highlights the importance of soil fertility in irrigation outcomes, as seen in Olayinka *et al*. (2018), where poor soil conditions were associated with suboptimal agricultural performance, even with adequate irrigation. Farmland-3 and Farmland- 4, which showed good irrigation output and varying improvements in production, demonstrate the positive impact of combining fertilizers with manure. This supports the findings of Bamikole *et al.* (2020), who found that integrated nutrient management, using both organic and inorganic fertilizers, significantly improves soil fertility and crop yields. The results from Farmland-4, where production significantly increased with fertilizer application alone, echo the research by Olufemi *et al.* (2019), which indicated that fertilizers can be particularly effective when soil fertility is moderate to high. Overall, these findings suggest that optimal soil fertility, appropriate irrigation techniques, and balanced nutrient management are essential for improving agricultural productivity.

## V. Conclusion

The study across four irrigated farmlands in Argungu reveals important insights into soil quality, nutrient stability, and implications for sustainable agricultural practices to fight food security. The monthly measurements of physicochemical variables demonstrated both stability and variability across farmlands, each contributing uniquely to soil fertility and crop health. This study also reveals the effectiveness of current soil management practices in maintaining nutrient stability across irrigated Farmland soils, with Farmland 1 exhibiting slightly more variability, potentially due to diverse crop rotation or differing soil amendments. These also suggest that while the farmlands are generally well- suited for agriculture, certain areas may benefit from targeted management practices to further optimize crop productivity and soil health.

## VI. Recommendations

This study therefore, recommends the following;

1. Enhance organic matter management for regular applications of organic matter.
2. Monitor pH levels, to maintain pH levels closer to neutral for optimizing nutrient availability.
3. Maintain EC within optimal range.
4. Conduct periodic soil analysis to track changes in soil nutrients and physicochemical properties.

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