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# Soil Physio-Chemical Variations in Monocropping and Mixed Cropping Systems; A Case Study from Kollam District, Kerala, India

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**KEYWORDS**

Mono crops, Mixed crops, Agricultural soil, Organic carbon, Micronutrient

**ABSTRACT:**

**Introduction:** A study was conducted to examine the physio-chemical properties of soil i monocropping and mixed cropping agricultural areas in Kollam district, Kerala, India. Th monocropping area, located in Perinad in the district focused on cultivating *Citrus limon* (lemon), whil the mixed cropping area in Anchalummodu involved in the cultivation of various vegetable crops.

**Objectives**: Study aims to examine the effects of monocropping and mixed cropping on soi characteristics and to enhance the understanding of how monocropping and mixed cropping system impact on soil health.

**Methods**: This study was conducted in two agricultural locations within the Kollam district of Keral state to compare soil characteristics between monocropping and mixed cropping systems. Soil sample were collected from both areas at two depths (0–15 cm and 15–30 cm) from selected sample plots Standardized laboratory procedures were followed to ensure accuracy and reliability in the analysis o physical and chemical properties of the soil, including soil pH, soil electrical conductivity (EC), soi moisture content, soil water-holding capacity, soil organic carbon, soil available phosphorus, so potassium, soil sulphur, and soil micronutrient levels (iron, zinc, copper, manganese, and boron). Th collected data were statistically analysed and correlation analysis was used to examine the relationship between different soil parameters.

**Results:** The results of the present investigation showed that in mixed cropping area soils maintained more stable pH range (6.20–6.30) compared to monocropping systems (6.02–6.13), thereby enhancin nutrient availability. Although soil moisture content and water-holding capacity were slightly higher i monocropping soils, but mixed cropping demonstrated improved nutrient cycling. Mixed cropped soil also exhibited higher concentrations of essential micronutrients such as manganese (40 ppm vs. 8 ppm) zinc (16.72 ppm vs. 12.64 ppm), and copper (6.6 ppm vs. 3.4 ppm) in the upper soil layer, indicatin better soil health. The distribution patterns of potassium and sulphur varied depending on soil depth an cropping system. Correlation analysis revealed significant relationships between soil parameters, soil pH showing a negative correlation with moisture content, organic carbon, and potassium. Overall, th findings highlight the advantages of mixed cropping in sustaining soil fertility and maintaining balance nutrient levels, thereby supporting sustainable agricultural practices.

**Conclusions**: The study highlights potential issues associated with monocropping, such as soil nutrien imbalances, which could lead to long-term soil degradation. The higher sulphur content and uneve potassium distribution observed in monocropping soils underscore the need for careful nutrien management. While both cropping systems offer certain advantages, the present study suggests tha mixed cropping may provide greater long-term benefits for soil health and sustainability, particularly i maintaining a balanced nutrient profile and enhancing soil structure.

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## 1. Introduction

Soil is a vital component of agriculture, acting as a medium that supplies essential nutrients, water, and structural support for plant growth. It functions as a dynamic ecosystem shaped by environmental factors such as climate, topography and biological activity. Understanding the physicochemical properties of soil is essential for sustainable agriculture, as these properties influence soil fertility, crop yield, and overall environmental health (11). Effective soil management is crucial for maintaining productivity and preventing degradation, especially since different farming practices can significantly affect soil characteristics.

Monocropping and mixed cropping are two widely practiced farming systems, each with distinct effects on soil health and agricultural sustainability. Monocropping, also known as solo cropping or monoculture, involves cultivating a single crop species repeatedly on the same land. This approach enhances efficiency by allowing specialized farming techniques, optimized resource use, and higher yields through targeted management practices (12). However, despite these advantages, monocropping can have significant long-term consequences for soil health. Repeated cultivation of the same crop depletes soil nutrients, reduces organic matter content, and increases susceptibility to pests and diseases, often leading to a higher dependence on chemical fertilizers and pesticides (14). Over time, monocropping can also cause soil compaction, alter soil pH, and reduce microbial diversity, ultimately degrading soil fertility and structure (6). Conversely, mixed cropping, also known as intercropping or polyculture, involves cultivating multiple crop species simultaneously on the same land. This approach is widely recognized for its ability to enhance soil fertility, optimize resource use, and improve resilience to environmental stressors. By combining crops with varying nutrient requirements and root structures, mixed cropping facilitates more efficient nutrient and water utilization, thereby reducing dependence on chemical fertilizers (9).

Given the profound influence of cropping systems on soil health, it is crucial to evaluate the physicochemical properties of soil under different agricultural practices. This study aims to examine the effects of monocropping and mixed cropping on soil characteristics, focusing on factors such as nutrient availability, organic matter content, soil pH, and water retention capacity. By gaining insights into these relationships, farmers and policymakers can make informed decisions to enhance soil fertility, boost crop productivity, and promote the sustainability of agricultural practices. This study aims to enhance the understanding of how monocropping and mixed cropping systems impact soil health. By analyzing key soil characteristics, it seeks to offer practical guidelines for sustainable agriculture, promoting long-term soil fertility and environmental conservation.

## 2. Study area and Methods

The present study was conducted in two agricultural locations within the Kollam district of Kerala to compare soil characteristics between monocropping and mixed cropping systems. The first site, situated in Perinad, approximately 8.5 km from Kollam city center, was dedicated to the monocropping of *Citrus limon* (lemon). The second site, located in Anchalummodu, about 7.00 km from Kollam city center, represented a mixed cropping system with various vegetable species, including *Amaranthus dubius* (red spinach), *Spinacia oleracea* (spinach), *Momordica charantia* (bitter gourd), *Coccinia grandis* (ivy gourd), *Trichosanthes cucumerina* (snake gourd), and *Capsicum annuum* (chili pepper).

For the present study, three sample plots of area 1.5 × 1.5 meters were randomly selected in each area. From each plot, three soil samples were collected by digging a 30 cm deep pit using a spade. Soil samples were taken from two distinct layers; 0–15 cm (top layer) and 15–30 cm (bottom layer). Care was taken to avoid mixing soils from different layers. Soil from each layer was placed in a clean polythene bag. Approximately 500 grams of soil from each layer were collected, properly labelled, and transported to the laboratory for further analysis. The collected soil samples underwent various physical and chemical analyses to compare soil characteristics between monocropping and mixed cropping systems. Standardized laboratory procedures were followed to ensure accuracy and reliability in each analysis. The parameters studied included soil pH and electrical conductivity described by (3). Soil moisture content, water-holding capacity, organic carbon percentage were analysed by using standard method (10).

Phosphorus availability was determined using (1) and modified by (2). Potassium was estimated using the method by (7). Sulphur availability in the soil was determined using the method of (10). Soil micronutrient like iron (Fe), manganese (Mn), zinc (Zn), copper (Cu) and boron (B) levels were determined by using the above method. The collected data were statistically analyzed. Correlation was used to examine relationships between different soil parameters. It helped in understanding the extent to which cropping systems influenced soil properties, providing insights into soil fertility variations under different agricultural practices.

## 3. Results and Discussion

The findings of the present study provide insights into various soil factors influencing plant growth, highlighting the effects of different cropping systems on soil health and nutrient availability. Soil physical parameters such as soil pH has a crucial role in nutrient availability and plant growth. In monocropping areas, the pH was slightly acidic, with an average value of 6.13 and 6.02 in the upper and lower layers respectively. While in mixed cropping areas, the pH was slightly higher, with an average value of 6.20 and 6.30 respectively (Fig. 1). The result indicates in mixed cropping system helped to maintain a more stable pH, contributing to better nutrient cycling, which is important for sustainable farming practices.

Soil moisture is essential for plant growth, as it facilitates nutrient transport and maintains hydration. In monocropping areas, the average soil moisture content was 24.32% in the upper layer and in mixed cropping system it was 24.15% (Fig 2). Factors such as organic matter, soil texture, and biological activity likely influenced this trend. A research study on agricultural lands resulted that soil moisture content can vary between 10% and 35% depending on irrigation practices and crop type (4). Comparing the average water holding capacity in the soils of the two cropping systems resulted that in monocropping areas, the upper layer had a water holding capacity of 90% and that of lower layer was 60%. In mixed cropping system the results were 84% and 78% respectively (Fig. 3). However, the electrical conductivity (EC) in the upper layer of monocropping areas was 0.10 mhos/cm and that of lower layer was 0.09 mhos/cm. In the mixed cropping system, the results were 0.10 mhos/cm and 0.08 mhos/cm respectively (Fig. 4). All values were within a range suitable for plant growth, suggesting that soil salinity was not a limiting factor in either cropping system. A study was found that soils with an electrical conductivity of less than 0.8 mhos/cm do not typically affect crop yields (13).

Analysing the soil organic carbon, in monocropping areas the average values were 1.73% and 1.35% in the upper and lower layer respectively (Fig. 5). The results may be due to the factors such as leaching, tillage practices, and root distribution, with monocropping systems potentially leading to greater organic matter depletion over time (8). While soil phosphorus in both monocropping and mixed cropping areas contained over 33 kg/ha of available phosphorus, indicating sufficient availability for plant uptake. However, excessive phosphorus can lead to nutrient imbalances, especially affecting zinc and iron levels. Analysing the soil potassium, in monocropping areas, potassium levels were 89.6 kg/ha in the upper layer and 179.2 kg/ha in the lower layer. In mixed cropping areas, potassium levels were 112 kg/ha in the upper layer and 134.4 kg/ha in the lower layer (Fig. 6). The higher potassium concentrations in the lower layers of both areas may be attributed to natural soil processes, soil texture, and patterns of crop nutrient uptake. Proper management of potassium is essential for maintaining soil fertility and crop productivity, particularly in monocropping systems (5).

Sulphur is important for plant growth and development. In monocropping areas, available sulphur levels were higher in the lower soil layer (34.3 ppm) compared to the upper layer (16.4 ppm), likely due to fertilizer application (Fig. 7). In mixed cropping areas, sulphur levels were lower, with 9.46 ppm in the upper layer and 11.45 ppm in the lower layer. The lower sulphur content in mixed cropping areas could be attributed to different plant species absorbing sulphur at varying rates, influencing its availability in the soil. However, iron is crucial for chlorophyll production and photosynthesis. In monocropping areas, iron content was 110.74 ppm in the upper layer and 115.72 ppm in the lower layer. The corresponding values in mixed cropping areas were 15.74 ppm and 34.72 ppm respectively in upper and lower layers (Fig. 8). The significant reduction in iron content in the lower layer of mixed cropping areas could be due to factors like nutrient competition and soil composition.

Soil zinc plays a role in plant growth and enzyme activation, was more abundant in mixed cropping areas. The average zinc content was 12.64 ppm in the upper layer and 10.31 ppm in the lower layer of monocropping areas. In mixed cropping areas, the results were 16.72 ppm in and 11.49 ppm respectively in upper and lower layers (Fig. 9). However, when analysing the soil available

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copper, values were higher in mixed cropping areas. In monocropping areas, available copper content was 3.4 ppm in the upper layer and 3 ppm in the lower layer, whereas in mixed cropping areas the results were 6.6 ppm in the upper layer and 3.2 ppm in the lower layer (Fig 10). Proper copper management in monocropping systems is essential to prevent nutrient imbalances and maintain soil health. Manganese, essential for plant metabolism, was found in significantly higher concentrations in the mixed cropping areas. In monocropping areas, manganese content was 8 ppm in the upper layer and 9 ppm in the lower layer. In mixed cropping areas, it was 40 ppm and 31 ppm respectively (Fig. 11). The higher manganese content in mixed cropping areas can be attributed to factors such as low soil pH, high organic matter, and moisture content, which favor its availability.

Boron plays a crucial role in cell wall formation and nutrient transport. In monocropping areas, the average soil available boron content was 1.15 ppm in the upper layer and 1.24 ppm in the lower layer. In mixed cropping areas the results were 1.3 ppm and 1.55 ppm respectively in upper and lower soil layers (Fig. 12). The increase in boron content with soil depth may be related to its availability in acidic soils, where boron is more soluble. The study reveals that mixed cropping systems generally lead to better soil health, nutrient cycling, and more stable nutrient levels compared to monocropping systems. The higher concentrations of manganese, zinc, and copper in mixed cropping areas indicate better nutrient availability, while the more stable pH and water retention properties suggest improved soil quality (15).

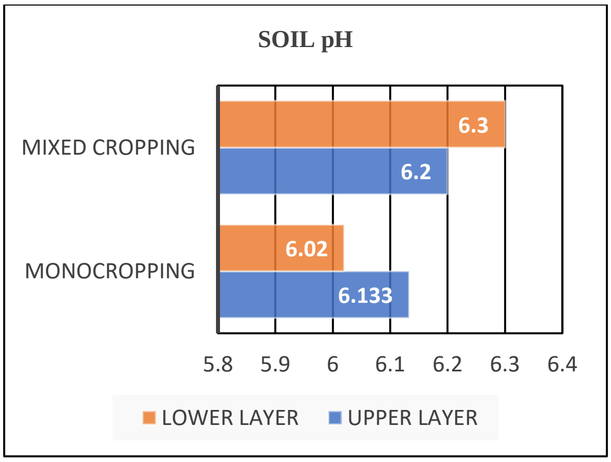


**Fig. 1 Soil pH**

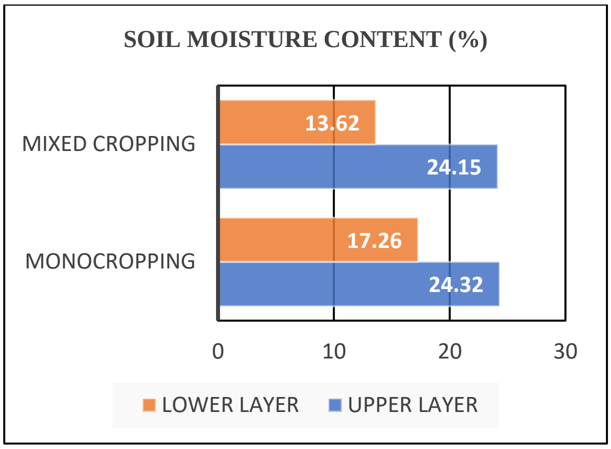


**Fig. 2 . Soil moisture content**

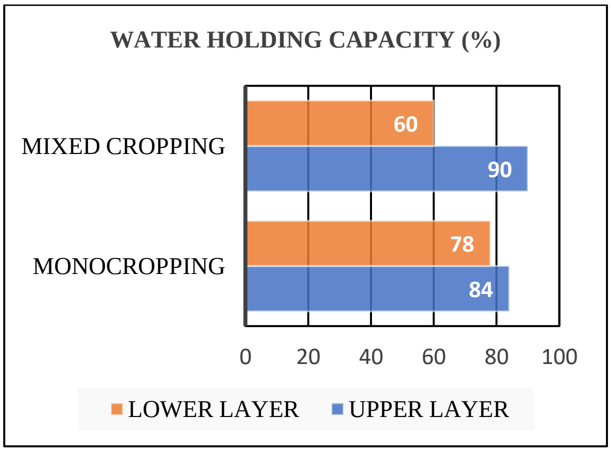


**Fig .3. Water holding capacity**

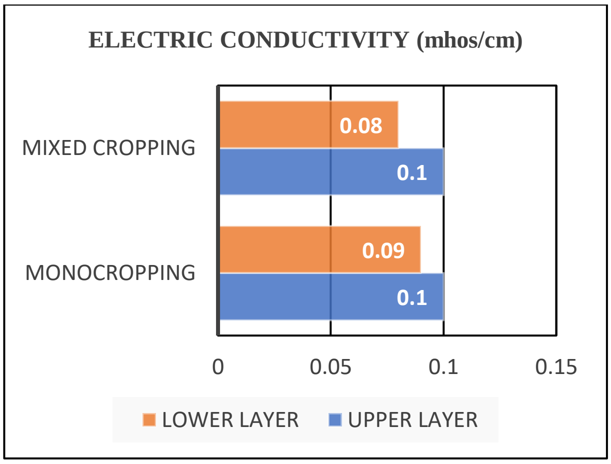


**Fig. 4. Soil Electric conductivity**

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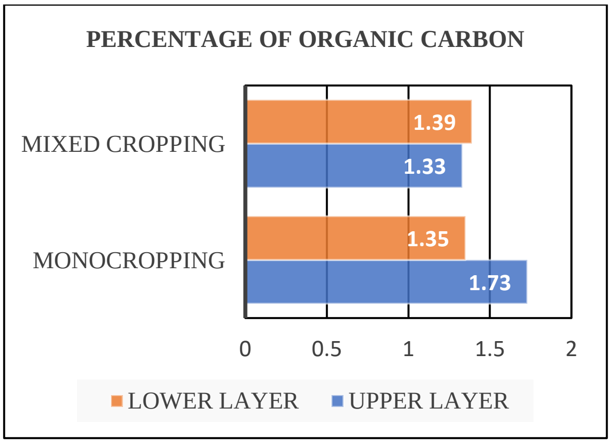


**Fig. 5. Soil Organic Carbon**

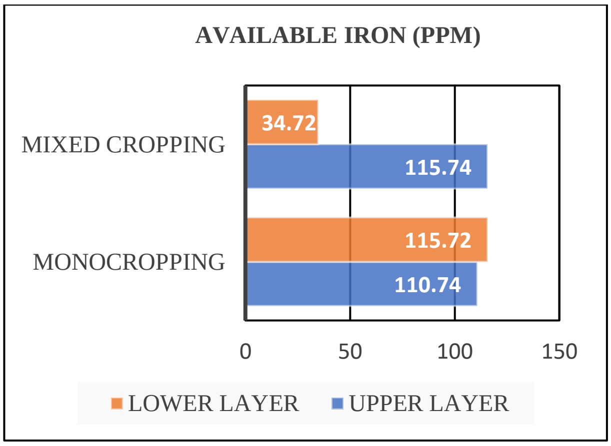


**Fig. 8. Available Iron**

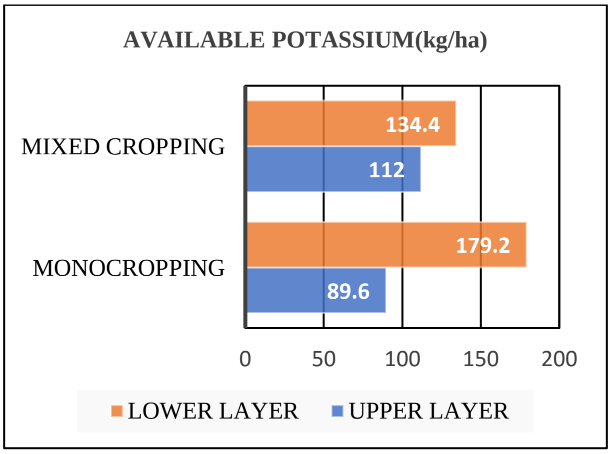


**Fig 6. Available potassium**

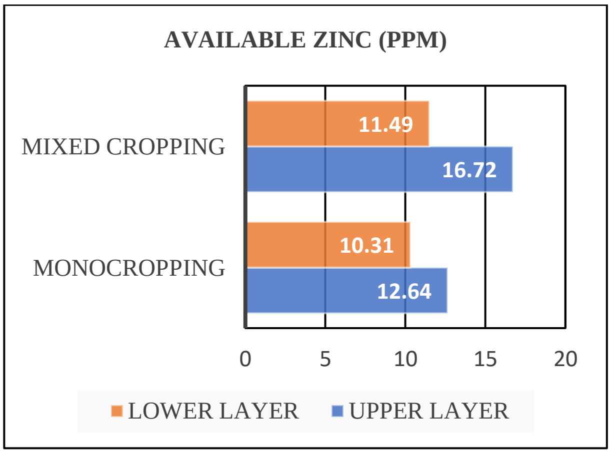


**Fig. 9. Available Zinc**

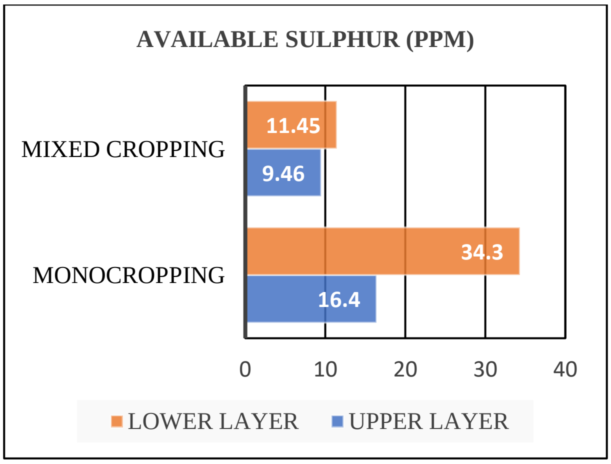


**Fig 7. Available Sulphur**

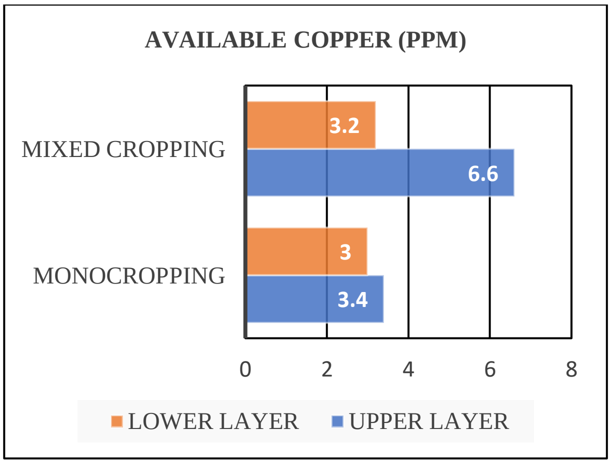


**Fig. 10 Available Copper**

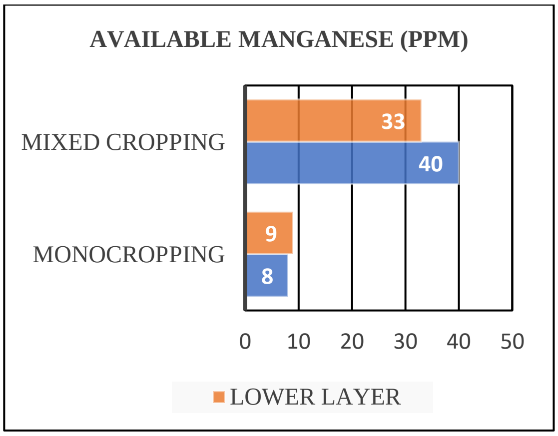


**Fig 11. Available Manganese**

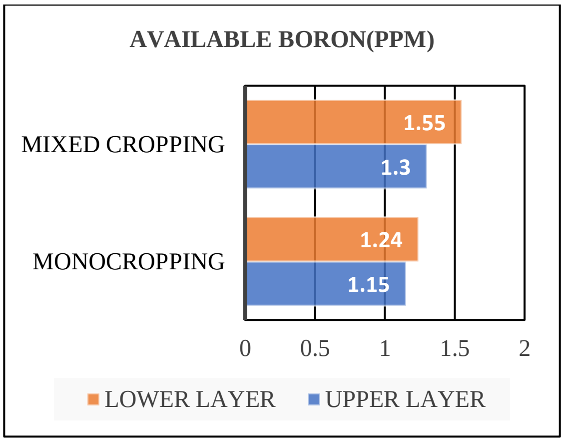


**Fig. 12. Available Boron**

A correlation matrix was prepared and the results shows that how strongly different variables are related. In this study, soil pH is negatively correlated with soil moisture content, water holding capacity (WHC), electrical conductivity (EC), organic carbon (OC), and K. Similarly, K is negatively correlated with pH, moisture content, water holding capacity (WHC), electrical conductivity (EC), and P. Nutrients like Mn and K are also negatively correlated with soil moisture content, water holding capacity, organic carbon (OC), and S (Table 1).

**Table 1. Correlation matrix of the parameters**

| | **pH** | **Soil mo.** | **WHC** | **EC** | **OC** | **P** | **K** | **S** | **Fe** | **Zn** | **Cu** | **Mn** | **B** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 1 | | | | | | | | | | | | |
| **Soil mo.** | **-0.24** | 1 | | | | | | | | | | | |
| **WHC** | **-0.71** | 0.35 | 1 | | | | | | | | | | |
| **EC** | **-0.38** | 0.99 | 0.41 | 1 | | | | | | | | | |
| **OC** | **-0.10** | 0.46 | 0.76 | 0.4 | 1 | | | | | | | | |
| **P** | 0.15 | 0.89 | 0.24 | 0.8 | 0.63 | 1 | | | | | | | |
| **K** | **-0.4** | **-0.7** | **-0.1** | **-0.6** | **-0.66** | **-0.9** | 1 | | | | | | |
| **S** | **-0.87** | **-0.3** | 0.55 | -0.1 | -0.1 | -0.6 | 0.77 | 1 | | | | | |
| **Fe** | **-0.77** | 0.76 | 0.52 | 0.9 | 0.15 | 0.38 | **-0.05** | 0.4 | 1 | | | | |
| **Zn** | 0.33 | 0.7 | **-0.4** | 0.6 | **-0.12** | 0.69 | **-0.6** | **-0.7** | 0.3 | 1 | | | |
| **Cu** | 0.24 | 0.59 | **-0.5** | 0.6 | **-0.34** | 0.5 | **-0.38** | **-0.6** | 0.4 | 0.96 | 1 | | |
| **Mn** | 0.73 | **-0** | **-0.9** | **-0.1** | **-0.59** | 0.1 | **-0.2** | **-0.7** | **-0.3** | 0.69 | 0.74 | 1 | |
| **B** | 0.78 | **-0.8** | **-0.8** | **-0.8** | **-0.53** | **-0.5** | 0.21 | **-0.4** | **-0.9** | **-0.10** | **-0.06** | 0.6 | 1 |

The present study highlights potential issues with monocropping, such as soil nutrient imbalances, which could lead to long-term soil degradation. The higher sulphur content and uneven potassium distribution in monocropping soils indicate the need for careful nutrient management. However mixed cropping appears to offer benefits for soil health by enhancing the availability of micronutrients and maintaining more consistent nutrient levels across soil layers. This practice may help to sustain soil fertility over time and reduce the risk of soil degradation. Regular monitoring of soil physio-chemical properties is essential in both monocropping and mixed cropping systems to ensure soil health and productivity. In this contest the present study suggests that while both cropping systems have their advantages, mixed cropping may provide better long-term benefits for soil health and sustainability, particularly in maintaining a balanced nutrient profile and improving soil structure.

**Acknowledgement**

All authors contributed equally

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