

The Relationship Between Soil Nitrogen Content and Soil Magnetic Susceptibility in UHO Agricultural Land

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Abstract: Soil plays an important role in supporting agricultural productivity through the availability of nutrients, particularly nitrogen, which affects plant growth and soil fertility. This study aims to determine the relationship between soil nitrogen content and soil magnetic susceptibility on agricultural land at Halu Oleo University (UHO) planted with corn, long beans, and chili peppers. Soil samples were collected at depths of 0 cm and 30 cm. Nitrogen content was analyzed using a spectrophotometer, while magnetic susceptibility was measured using an MS2B-type susceptibility meter. The results showed that both nitrogen content and soil magnetic susceptibility were higher in the surface layer and decreased at 30 cm. This indicates a relationship between soil nitrogen content and soil magnetic properties. In conclusion, nitrogen content influences variations in soil magnetic susceptibility. This study contributes to the development of a rapid, non-destructive alternative method for assessing soil fertility in agricultural land.

Keywords: Magnetic Susceptibility; Soil Nitrogen; UHO Agricultural Land.

Introduction

Soil is a crucial component in agricultural systems because it serves as a growing medium for plants and provides the nutrients needed to support agricultural productivity. [1] One of the macronutrients that significantly influences plant growth is nitrogen (N). Nitrogen plays a role in the formation of protein, chlorophyll, and vegetative plant growth. Low soil nitrogen levels can reduce agricultural yields, while excess nitrogen can negatively impact soil quality and the environment [2].

Nitrogen in the soil generally comes from organic matter, organic fertilizers, and nitrogen fixation by microorganisms. However, nitrogen is a highly dynamic element and easily undergoes changes in form through the processes of mineralization, nitrification, denitrification, and leaching [3]. The readily leachable nature of soil nitrogen often limits its availability in agricultural production [4,5]. Therefore, monitoring soil nitrogen content is very important to maintain nutrient balance and land sustainability.

Several studies have explored the relationship between soil's physical-chemical properties and other indicators that can be used to predict soil fertility. For example, a relationship between soil mineral structure and the levels of available nitrogen and phosphorus was demonstrated [6]. A study by Hanuf also revealed that soil physical parameters, such as porosity and bulk density, are correlated with nutrient availability at different soil depths [6].

In addition to its chemical aspects, soil characteristics can be studied through their physical properties, including soil magnetic susceptibility. Magnetic susceptibility is a parameter that describes the soil

material's ability to respond to magnetic fields and is influenced by the content of magnetic minerals, such as iron oxides. The value of soil magnetic susceptibility is known to be related to pedogenesis, organic matter content, and the biological and chemical activity of the soil [7].

Soil magnetic susceptibility is a physical parameter that describes the soil's response to an external magnetic field. This value is influenced by the content and distribution of magnetic minerals such as magnetite and hematite, which can be influenced by pedogenesis processes, organic matter content, and the chemical and biological activity of the soil. [8] Thus, changes in soil nitrogen content can indirectly affect variations in soil magnetic susceptibility.

Several studies have shown that nutrient content, particularly nitrogen, is linked to changes in soil magnetic properties. The activity of soil microorganisms, influenced by nitrogen availability, can trigger the transformation of iron minerals, potentially affecting magnetic susceptibility values [9]. Therefore, magnetic susceptibility measurement can be a rapid, non-destructive alternative for indicating soil fertility conditions.

In addition, the magnetic properties of soil have attracted attention as indicators of soil potential because they are influenced by magnetic minerals associated with pedogenic processes and by the presence of heavy metals [10]. Wahyuni found a relationship between soil magnetic susceptibility values and the level of heavy metal pollution in agricultural land exposed to industrial waste [11].

The agricultural land at Halu Oleo University (UHO) is used for agricultural and research activities, so comprehensive information on its soil conditions is needed. To date, studies linking soil nitrogen content to magnetic properties on Halu Oleo University's agricultural land

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remain limited. This research is expected to provide an overview of the relationship between soil nitrogen content and magnetic susceptibility and contribute to the development of more efficient and applicable soil fertility evaluation methods in agriculture.

Some of the opinions above indicate that soil with high nitrogen and organic matter content tends to exhibit different magnetic susceptibility values than soil with low nitrogen content. This shows that magnetic susceptibility can serve as an indicator of the relationship between soil nitrogen and magnetic susceptibility, which is important for understanding the interactions among chemical, biological, and physical processes in soil [12].

Nevertheless, there are very few studies that directly examine the relationship between soil nitrogen content and soil magnetic susceptibility in tropical agricultural lands, particularly across different crop types such as corn, long beans, and chili peppers. Previous studies have largely focused on the relationship between soil magnetic properties and other parameters, such as heavy metals or mineral composition, without explicitly linking them to nitrogen as an indicator of soil fertility. This unresolved gap serves as the basis for the present study. Therefore, this research was conducted to investigate the relationship between soil nitrogen content and soil magnetic susceptibility on agricultural land at Halu Oleo University (UHO), with the expectation that the results will provide new insights into rapid, non-destructive approaches for evaluating soil fertility.

Research Methods

This research is a purely experimental study. The study analyzed the relationship between soil nitrogen and the magnetic susceptibility of soil planted with chilies, long beans, and corn in the Faculty of Agriculture's Land Laboratory 1, where soil depths varied from the surface to 30 cm.

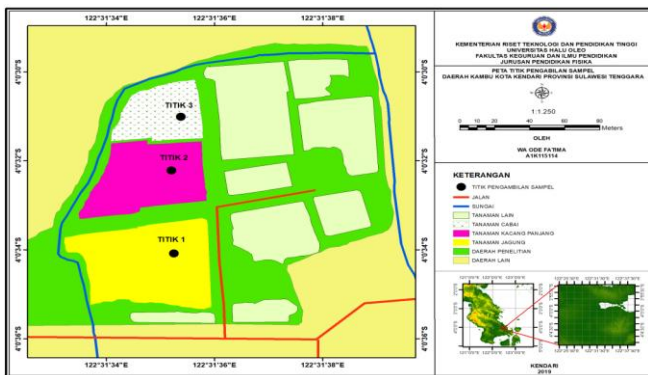


Figure 1. Field Laboratory Sampling Area, Land 1 UHO.

The population of this study was the land of the Faculty of Agriculture Field Laboratory, Land 1, which was planted with chilies, long beans, and corn. Each plant had a distance between one another. The distance between corn and long beans was ± 10 meters, while the distance between long beans and chilies was ± 5 m. The sampling process was carried out at one point on the land planted with chilies, long beans, and corn, Faculty of Agriculture Field Laboratory, Land 1.

The variables in this study include independent and dependent variables. The independent variable is the variable that influences or causes changes in, or the emergence of, the dependent variable, while the dependent variable is the variable that is influenced by, or becomes the result of, the independent variable. The independent variable is the soil in the Field Laboratory of the Faculty of Agriculture, Land 1, which is planted with chilies, long beans, and corn, while the dependent variables are the soil nitrogen content and soil magnetic susceptibility, as well as the relationship between soil element content and magnetic susceptibility. The tools and materials used in this research are shown in Table 1.

Table 1. Research Tools and Materials

No.	Names of tools and materials	Utility
1	GPS (<i>Global Position System</i>)	Determine the geographical point where the sample will be taken
2	Analytical Balance	Measuring the mass of the sample
3	Soil Drill	Taking Samples
4	Land 1 of UHO Faculty of Agriculture	As a research object
5	Label Paper	Provide labels on samples
6	Mortal	Grind the sample to make a fine powder
7	Alcohol	Clean mortar before use
8	Plastic Bag	As a sample place
9	Plastic Spoon	Scoop out samples
10	Sieve	Separating smaller particle parts
11	One laptop init	Processing sample data from measurement results
12	Spectrophometer	Analyzing soil nitrogen content
13	<i>Susceptibility meter</i> tipe MS2B	Analyzing the magnetic properties of soil

The steps that have been taken in this research include:

- Field Sampling Stage**
Prior to sampling, observations were conducted at the target sampling site. The samples were from the soil in the UHO Faculty of Agriculture Field Laboratory, field 1, planted with chilies, long beans, and corn, with varying depths, including the surface layer and a 30 cm depth. Sampling was carried out using a soil auger.
- Sample Labelling**
Samples are labelled using label paper. This ensures that samples are not mixed up during analysis.
- Sample Drying**
Samples taken at varying depths are then dried to avoid any undesirable effects that could hinder the process.
- Sample Grinding**
The samples were ground using a mortar. The samples were ground for elemental content analysis, while the magnetic properties were not ground. The purpose of grinding was to fine-tune the soil particles. Care must be taken during this grinding process to ensure the samples were not mixed with other substances to maintain their

purity. Therefore, the mortar was cleaned with alcohol before use.

5. Sifting

Once the soil is sufficiently fine, the sample is sieved using a 200-mesh sieve. The sieved sample is then placed in a sample bag for further processing.

6. Analysis of soil nitrogen, carbon and phosphorus content using a spectrophotometer was carried out in the soil science laboratory of the UHO Faculty of Agriculture.

7. Analysis of the magnetic properties of the soil using a type MS2B susceptibility meter was carried out in the UHO MIPA Physics laboratory.

The analysis of soil nitrogen content using a spectrophotometer was conducted at the Soil Science Laboratory, Faculty of Agriculture, Halu Oleo University (UHO), following the soil nutrient analysis method applied by Sagiarti [12]. The analysis of soil magnetic properties using an MS2B-type susceptibility meter was conducted at the Physics Laboratory, Faculty of Mathematics and Natural Sciences (FMIPA), UHO, following the procedure for soil magnetic susceptibility measurement used by Rangkuti and Enim[13].

The data analysis techniques used in this study are:

1. Determination of soil nitrogen content is carried out through spectrophotometer analysis.
2. Determination of soil magnetic susceptibility using equation (3).
3. Graph of soil nitrogen content versus depth variation.
Graph of soil magnetic susceptibility versus depth variation.

The determination of soil nitrogen content was carried out using spectrophotometric analysis [14-15].

Results and Discussion

This research was conducted at the UHO Faculty of Agriculture Field Laboratory 1 in a wetland. In this study, samples were analyzed for available soil nitrogen content in fields planted with corn, long beans, and chilies, as well as their magnetic susceptibility. Samples analyzed for nitrogen content were sieved through a 200-mesh sieve using a spectrophotometer. Meanwhile, the soil magnetic level was analyzed using a Bartington Susceptibility Meter type MS2B. The results of the MS2B analysis depend on the sample mass; its magnetic properties are then detected.

Soil Elemental Content Based on Spectrophotometer Analysis

The results of the analysis of soil Nitrogen (N) content using a spectrophotometer for corn, long bean, and chili plants at soil depths of 0 cm and 30 cm are shown in Table 2.

The table above shows that the available nitrogen content in the soil for corn, long beans, and chili plants decreases with depth, which will affect plant fertility. This phenomenon is consistent with the study by Camila [16], which showed that nutrient contents such as nitrogen tend to be higher in the surface layer due to fertilizer application and the accumulation of organic matter. In addition, the Ultisol soils that dominate this agricultural land have a

limited nutrient retention capacity in the deeper layers, resulting in a decrease in nitrogen content with increasing depth [17].

Table 2. Results of Spectrophotometer Observations on the Elemental Nitrogen Content of Soil Sifted through 200 Mesh.

Element (%)	Plant type/depth					
	Corn (cm)		Long beans (cm)		Chilli (cm)	
	0	30	0	30	0	30
N	0.07	0.05	0.06	0.04	0.09	0.04

The graph of element concentration versus depth is shown in Figure 2.

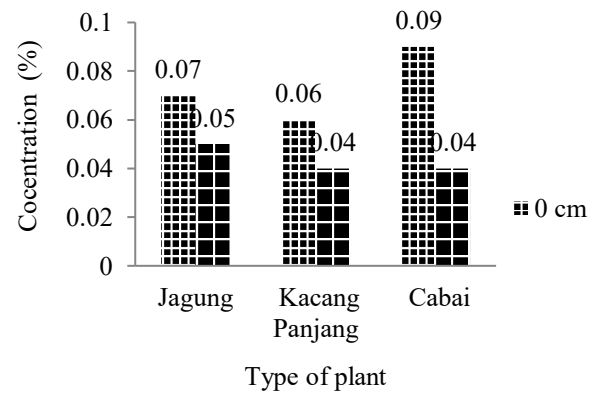


Figure 2. Comparison Chart of Nitrogen in Soil Elements

Based on these results, differences in nitrogen content across soil depths affect plant nutrient availability. Higher nitrogen levels in the surface layer support vegetative growth, whereas lower nitrogen levels in deeper layers can limit nutrient uptake by roots that penetrate deeper into the soil. This underscores the importance of proper fertilizer management and crop rotation to maintain uniform soil fertility [18].

Soil Magnetic Susceptibility in Agricultural Land Planted with Corn, Long Beans, and Chili Peppers

Analysis of soil magnetic properties was conducted at low and high frequencies. The results of soil magnetic level observations using the MS2B are shown in Table 3.

Table 3. Results of Observations of Soil Magnetic Properties Based on MS2B Analysis

Frequency	Type of Plant					
	Corn (cm)		Long Beans (cm)		Chilli (cm)	
	0	30	0	30	0	30
χ_{LF} ($10^{-8} \text{ m}^3/\text{Kg}$)	44.6	15.4	110.9	73.8	120.3	47.8

Table 3 shows that the soil magnetism level of the same plant decreases with depth. Measurements of magnetic susceptibility showed a trend with soil depth. Surface soil exhibited higher values than soil at 30 cm depth. For example, in chili pepper plots, the surface soil magnetic susceptibility was $120.3 \times 10^{-8} \text{ m}^3/\text{kg}$, whereas at 30 cm depth it decreased to $47.8 \times 10^{-8} \text{ m}^3/\text{kg}$. This

difference indicates that the surface soil layer contains a higher amount of ferromagnetic minerals, likely due to pedogenic processes, organic matter accumulation, and microbial activity influencing iron mineral transformations [19]. Deeper soil layers exhibited lower values because the magnetic mineral content is relatively lower and mixed with diamagnetic particles [20].

Based on these results, magnetic susceptibility can be used as an indicator of soil fertility, as it is related to the content of magnetic minerals and soil biological activity. These findings are consistent with the study by Budiman, which showed a positive correlation between soil magnetic susceptibility, organic matter content, and soil fertility levels [21]. In addition, the frequency-dependent values indicate that the soil is a mixture of superparamagnetic and non-superparamagnetic grains, which affects its response to an external magnetic field [22].

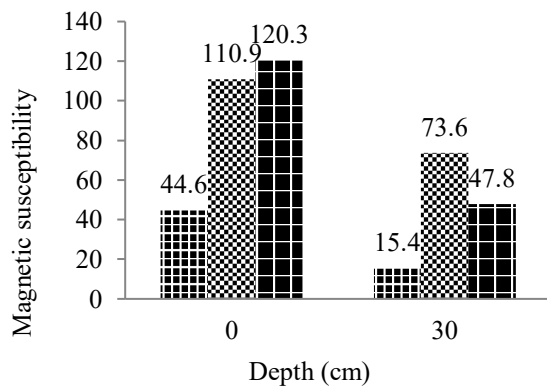


Figure 3. Soil Magnetic Susceptibility in Corn, Long Beans, and Chili Plants

The analysis of the relationship between soil nitrogen content and magnetic susceptibility revealed a consistent pattern: soils with higher nitrogen levels tended to exhibit higher magnetic susceptibility. This supports the hypothesis that microbial activity and organic matter content, influenced by soil nitrogen, can trigger iron mineral transformations, thereby increasing soil magnetism[23]. This phenomenon also supports previous findings suggesting that magnetic susceptibility can serve as a rapid, non-destructive method for estimating soil fertility, particularly in agricultural lands with varying nitrogen content [24].

Conclusion

Based on the results obtained from this research, it can be concluded that, the nitrogen content of the soil above the surface and at a depth of 30 cm in corn, long beans and chili plants is the largest in chili plants on the surface and corn at a depth of 30 cm, while the smallest is in corn plants on the surface and chili plants at a depth of 30 cm. The magnetic susceptibility value is greatest in chili plants on the surface and in long bean plants at a depth of 30 cm, and the smallest in corn plants.

Author’s Contribution

W. O. Fatima: contributed to the formulation of the research idea, soil sampling at the UHO farmland, soil magnetic susceptibility measurements, data analysis, and

the initial draft of the manuscript. W.O.F.A Yfandi: contributed to the analysis of soil nitrogen content, interpretation of the relationship between nitrogen content and magnetic susceptibility, and review and refinement of the manuscript. Asni: contributed to the design of the research methodology, data validation, supervision of the research implementation, and final revision of the manuscript. W.O.N.A. Taporanggi, Risna, P.N. Aisyah, & Wa Sina: played a role in research supervision and in monitoring the implementation of research in the field and the laboratory. All authors have read and approved the final manuscript.

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