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Magnetic Susceptibility Profile, Fe Content and pH Analysis of Apple Orchard Soil and the Relation to Fruit Diameter

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Abstract: The measurement of magnetic susceptibility, pH, element concentration of Fe and apples diameter has been conducted in orchard soil of Malang, East Java Indonesia. The measurement was performed in two orchards, namely Pujon and Poncokusumo with two different kind of apples in each orchard. This research aimed at exploring in detail linked between magnetic properties, the existence of magnetic mineral as magnetic property carrier in the soil, soil pH, as well as the size of apple diameter to evaluate the quality of apple production in the both areas. The results show that the soil with lower susceptibility, it was expected that the magnetic mineral of magnetic property carrier to be smaller, low soil pH, meaning that the soil was more acidic which implied on a larger size of apple diameter for Rumbeauty type of apple. Meanwhile, when the soil had a higher susceptibility, and it is expected that the magnetic mineral is also high as well as having high pH, this growing media is appropriate to develop Manalagi type of apple. Based on the observed soil magnetic properties and pH from both observed orchards, it can be suggested that Manalagi apple is appropriate to be planted in Poncokusumo area, while Rumbeauty is appropriate to grow in Pujon area.

Keywords: Magnetic susceptibility; Fe content; pH; Orchard soil; Apple diameter

Introduction

The properties of soil as the conventional growing media become a significant part of being analyzed since it is related to the nutritional supply for the plants. Studies on soil properties have been widely conducted on various types of planting land (Ayoubi et al., 2022; Lambert et al., 2008; Butnor et al., 2003; Kai & Kubo, 2020). For example, the study on clay mineral and its correlation with potassium formation in the land planted with paddy and other than paddy (Raheb & Heidari, 2011). Soil properties including different physical and chemical properties imply apple production (Clement et al., 2011; Delcourt et al., 2019; Kai et al., 2016; Letters, 2011; Sangode et al., 2010).

In this research, soil magnetic properties in the apple orchard land have been conducted and exploring how its linked with the apple production, in this case, is the apple diameter yielded. The study on soil magnetic properties primarily magnetic susceptibility has been widely studied for diverse interest (Jordanova et al., 2016). More specifically, the research on soil magnetic properties in the plantation land is also intended for understanding the soil condition. As an example of illustration to the difference between the pesticide-polluted soil and without pesticide (Agustine et al., 2013) and its correlation to soil magnetic properties with the existence of nematode fossils (Lourenço et al., 2015). This study on magnetic properties aimed to investigate in detail the soil magnetic properties and their impact on plants, both its quality and the amount of plant

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production. The measurement of soil magnetic properties is directly related to the iron element and magnetic mineral in the soil. The magnetic properties are controlled by the types, size of grain, quantity, and morphology of magnetic mineral in the soil. The benefits of Fe element in the plants have also been explored among them as the controller of the photosynthesis process (Briat et al., 2010; Donnini et al., 2013; Till et al., 2021). The existence of the iron element in the soil and its relation with soil acidity properties can be described that the more acidic the soil, the smaller the iron mineral since iron dissolves in acidic substance. The study on the impact of other elements such as the role of potassium on the plant production as explained by (Fractionation et al., 2013; von Bennewitz et al., 2011) and Phospor (Lima et al., 2020). In this research, the measurement of soil magnetic properties in this case magnetic susceptibility and soil pH as well as its relation with the size of the apple. The difference in susceptibility was proven to be highly sensitive on the change of magnetic mineral grain size, magnetic mineral morphology, as well as the type of magnetic mineral. Therefore, the measurement of magnetic susceptibility on a specific sample can be used as the indicator of change in type and morphology of magnetic minerals due to the environmental change (Kanu et al., 2014). Experimentally, the correlation between the size of magnetic mineral and magnetic susceptibility in the magnetic mineral with magnetite (Fe3O4) type has been proven. Generally, for natural magnetic mineral grain size, mainly iron oxide, the smaller the magnetite grain size, the lower the susceptibility (Zulaikah et al., 2017).

Method

This research was conducted to compare magnetic susceptibility, the content of Fe element and soil pH in both apple orchards in Pujon (with the area of 6000 meters) and Poncokusumo (with the area of 1000 meters), Malang East Java as well as studying the size of apples grown in both orchards. The daily average temperatures in Pujon and Poncokusumon ranged between 22.1 – 22.7 °C and 21.5 – 22.4 °C respectively. The samples were taken from 8 points in each orchard, Site A for Bengkaras Madirejo Village in Pujon and Site B for Gubuk Klakah Village in Poncokusumo. In each point, 8 samples were taken and given code according to the depth of sampling, for example, AT1.1 was the sample taken in Point 1 in Pujon orchard in the depth of 10 cm from the soil surface. Furthermore, each addition of 10 cm depth, one sample was taken. The maximum depth of soil taken was 80 cm. The soil sample was taken from each layer and put in the standard plastic holder sample of magnetic measurement. Each sample was measured its magnetic susceptibility using Bartington Susceptibility meter, MS2B. The measurement was conducted three times for each sub-sample, and its average value was taken. The four soil sample representatives from each orchard were tested its element content using XRF (X-Ray Fluorescence). The measurement of soil pH was conducted randomly in each orchard using pH meter, Takemura DM-5 range 3-8. The measurement of the circumference of the apple sample was done with 50 samples randomly in each orchard, and its average was calculated.

Result and Discussion

The data of soil magnetic susceptibility measurement results showed that the average range of magnetic susceptibility was 6.54 – 16.24 × 10^{-6} m^3/kg for Pujon and 9.39 – 18.49 × 10^{-6} m^3/kg for Poncokusumo. In the Pujon area orchard, the data showed that the deeper the soil sample position, the lower the magnetic susceptibility, or it could be stated that the magnetic susceptibility decreased on 8 points of sampling as shown in Figure 1. Meanwhile, in Pocokusumo, the range of magnetic susceptibility showed almost no change in the depth or no significant decrease. The figure displays that there is a tendency of different results for soil magnetic susceptibility variation from both orchards as the research objects. The average of Fe concertation was higher in Pujon which was 68.36 compared to Poncokusumo which was 65.64. The magnetic property is significantly related to the magnetic mineral grain size carrying the magnetic properties. Based on the characteristics, it can be known that the magnetic susceptibility in Pujon was relatively smaller than in Poncokusumo and it was expected that the magnetic mineral in the area was also smaller.

Based on the correlation between the existence of magnetic mineral and soil pH measure, it can be assumed that the lower the pH where the acidic level is higher, the magnetic grain decreases in size. This occurs since the magnetic mineral grain can dissolve in an acidic environment. This condition is also shown in Table 1, where the pH in Pujon is lower than in Poncokusumo. In detail, the measurement of the parameters can be seen in Table 1.

The measurement results of the apple diameter showed that two different types of apple tend to be different. Manalagi apples in Poncokusumo have an averaged bigger diameter compared to the ones in Pujon.

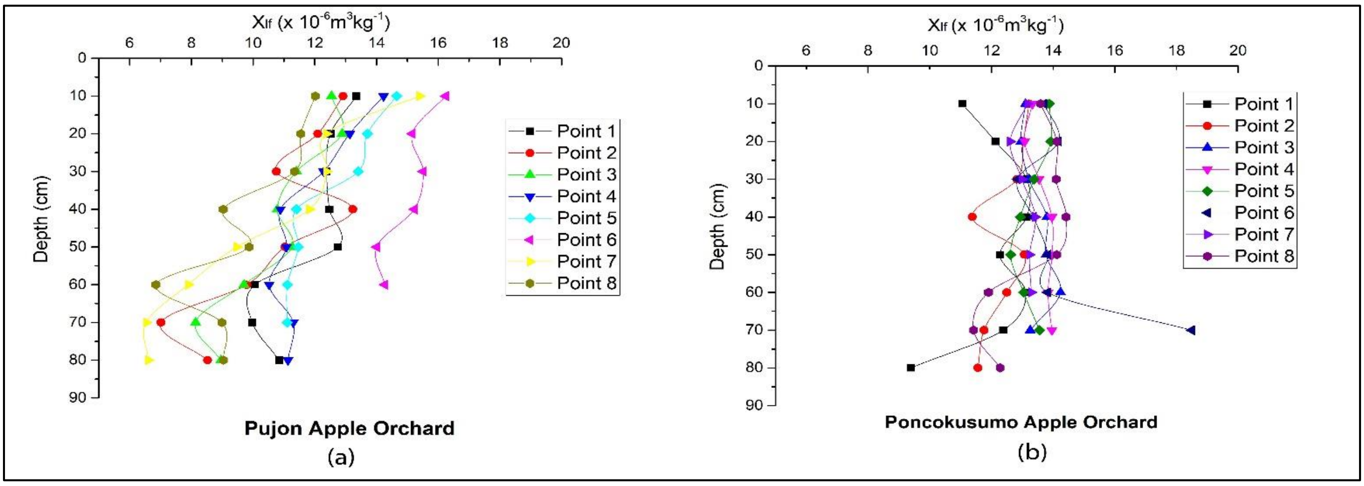

Figure 1. The profile of magnetic susceptibility on the depth of Pujon orchard (top) and Poncokusumo (below)

Meanwhile, the Rumbeauty type of apples in Poncokusumo tends to be smaller in averaged compared to the Pujon. Manalagi apples tend to be sweet, while Rumbeauty tends to be sour. Based on the pH measurement, it is known that the soil environment in the apple orchard in Pujon was more acidic compared to the one in Poncokusumo. Based on those tendencies, Rumbeauty apples are more appropriate to be grown in Pujon, where the land is more acidic, and Manalagi apples are more appropriate to be grown in Poncokusumo area with the lower soil-acidity level of the soil.

Table 1: The Results of Average Quantity Measurement of Magnetic Susceptibility in Pujon and Poncokusumo

Measured Quantity	Pujon	Poncokusumo
Range of Magnetic Susceptibility ($\times 10^{-6}$ m^3kg^{-1})	6.54–16.24	9.39 - 18.49
Concentration of Fe (Wt%)	68.36	65.64
Range of pH	6.60 – 7.00	6.80 – 7.00
Manalagi diameter (cm)	6.90	7.27
Rumbeauty diameter (cm)	7.15	6.62

According to the taste, Rumbeauty apples have a sourer taste which will be highly appropriate to be planted in the relatively high acidity soil. The soil pH condition was strongly expected to be able to be adjusted by giving fertilizers containing the iron substance which have certain particle size. However, the needs to be proven by laboratory testing and assisted with SEM analysis on the size of magnetic mineral grains extracted from the orchard soil. Based on the measurement of magnetic susceptibility which has a positive correlation with pH measurement, then the measurement of magnetic susceptibility is highly possible to be used as an alternative measurement of soil acidity level which can be applied in the agricultural environment. This can be recommended since the measurement of magnetic susceptibility is relatively affordable and feasible to be performed. By knowing the level of acidity in a various agricultural environment, then it is feasible to obtain the information on the acidity level which is appropriate with a specific plant growing land. One step which can be used as a consideration in the future, the researchers need to study further on whether the application of magnetic fertilizer in the form of specific magnetic mineral with certain grain size can maintain the soil to be more basic, enables better on the sweet taste of the fruit or sweetens it. The application of magnetic fertilizer on apple trees also significantly improved the production of apples, which positions on the second rank after the fertilization using fly ash (Bordeanu et al., 2015). The pattern of the pH level and magnetic susceptibility scores still require further research.

The average concentration of Fe in the soil is on the contrary with the average of magnetic susceptibility. This is caused by the existence of Fe element in the soil cannot be guaranteed to associate with other elements constructing ferromagnetic; accordingly, its susceptibility is higher. However, it may associate with other elements to form minerals enabling paramagnetic. Based on the measurement of magnetic susceptibility performed by Dearing (1999), it is known that the range of susceptibility obtained was susceptibility of paramagnetic materials. Furthermore, it needs to be explored in detail the effect of chemical and physical properties of soil as well as the existence of clay mineralogy in the soil on the supply of iron element as the controller of soil acidity properties (Raheb & Heidari, 2011).

Conclusion

Based on the tendency of the obtained data in this research, the smaller of susceptibility, the lower of pH and magnetic mineral grain size also small, it can be expected that the existence of an iron element in the soil can function as soil pH stability and fruit diameter controller. Although the difference of apple diameters was not high, the tendency of increasing and decreasing of magnetic susceptibility would has a lingkage. Based on data analysis, Manalagi, the sweeter apples are best to be grown in Poncokusumo, with magnetic susceptibility pattern of the depth of soil quite same from the top to the deeper soil, while Rumbeauty is best to be planted in Pujon, with magnetic susceptibility pattern from top to the deeper soil subsequently smaller.

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