



The Effect of Chemical Fertilizers on The Magnetic Susceptibility Value and Soil Fertility of Paddy Soils in Surantih, Kabupaten Pesisir Selatan

Received
9 September 2022

Revised
7 February 2023

Accepted for Publication
29 April 2023

Published
30 November 2023

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Abstract

Pesisir Selatan is a district where population depends on agriculture such as lowland rice. The rice seeds used were IR66. Efforts to improve the quality of Paddy soils seeds are fertilizing with chemical fertilizers. Chemical fertilizers used are Urea, KCL and Phonska. Continuous and excessive use of fertilizers will cause a decrease in the level of soil fertility due to the reaction between fertilizer minerals and soil minerals which also affects the magnetic susceptibility value. Based on these problems, further research was carried out to see the difference in the magnetic susceptibility value of paddy soils to the use of chemical fertilizers using the rock magnetism method with magnetic susceptibility parameters. The results showed that the paddy soil before and after being planted with rice seeds using chemical fertilizers decreased and increased the value of magnetic susceptibility due to the reaction between mineral fertilizers and soil minerals and waterlogging during the cultivation process. Meanwhile, the paddy soil before and after planting rice seeds that did not use chemical fertilizers decreased the magnetic susceptibility value quite far due to the absence of other mineral additions in the paddy soil such as chemical fertilizers.

Keywords: Magnetic Susceptibility; Paddy Soil; Chemical Fertilizer

1. Introduction

Pesisir Selatan is a district whose population depends on agriculture such as rice farming. One of the sub-districts that produce a lot of rice in Pesisir Selatan District is Sutera District, Surantih area to be exact. Rice is grown on a variety of Paddy soils[1][2]. Paddy land is land that is used to grow rice paddy throughout the year continuously or alternately with secondary crops. How to make land into rice fields is quite easy with the availability of sufficient air. Before the land is used as Paddy soils, the soil naturally undergoes a process of soil formation according to the factors that make it up. When the Paddy soils are then used for farming, there is a change in their physical and chemical properties [3].

Efforts to study Paddy soils can be done with several approaches, one of which is using the rock magnetism method. Magnetic minerals is one of the materials found in nature that contains a magnetic value. Magnetic minerals have weak (diamagnetic), moderate (paramagnetic) and strong (Ferromagnetic) magnetic properties. Of the three properties of magnetic materials, only ferromagnetic are referred to as magnetic[4].The method understands the properties of various mineral types in sediments, rocks and soils and the processes involved in their formation. Properties that are often used as indicators of soil development, especially to determine soil iron oxides and their properties. One of the parameters of the rock magnetism method that can be used to see the nature of soil types is species susceptibility.

Magnetic susceptibility is a quantity that expresses the susceptibility of a material to an external magnetic field (H). When an external magnetic field is applied, there is a rectification of the magnetic moment to the direction of the external magnetic field, which is called magnetization (M) [5].

$$(M \rightarrow) = \chi (H \rightarrow) \dots\dots\dots (1)$$

Where $(M \rightarrow)$ is the magnetic intensity in A/m, (χ) is the susceptibility value of a material and has no dimensions and $(H \rightarrow)$ is the magnetic field strength in A/m. The value (χ) is the basic parameter used in the magnetic method [6]. The value of soil magnetic susceptibility is closely related to the minerals contained in the soil. Soil minerals can be influenced by several things, namely the environment and conditions of soil formation, erosion processes, leaching, carrying by agricultural products and improper fertilization due to reactions between mineral fertilizers and rice soil minerals [7]. In addition, waterlogging during rice growth can reduce Fe and Mn which seeps into the underground layers causing different soil mineral content.

Soil mineral properties are closely related to the level of soil fertility [8]. The minerals present in the soil can indicate how many nutrients are contained in it. In general, minerals that are often found in soil are biotite, calcite, plagioclase, pyroxene, hornblende, quartz, opaque and clay. Biotite minerals are minerals that contain nutrients needed by seeds to stimulate the formation of root hairs, the formation of green leaves and so on such as elements of Potassium (K), Magnesium (Mg) and Iron (Fe) [9]. The higher the level of soil fertility, the better the yield of the seeds planted. One of the efforts to improve the quality of Paddy soils seeds is fertilization [10].

Fertilizer is an important factor in efforts to produce agricultural products [11][12]. There are two types of fertilizers on the market, namely organic and inorganic fertilizers. One of the fertilizers used by farmers is inorganic fertilizer. Inorganic fertilizers have various benefits for plants, one of which is greening leaves, strengthening roots, fertilizing plants and increasing fruit. Continuous and excessive use of fertilizers and improper fertilization or low soil organic matter content will cause a decrease in soil fertility [13].

Besides, the use of inorganic fertilizers also affects the magnetic susceptibility value of the soil [14]. It is known from the magnetic susceptibility value of former agricultural land using chemical fertilizer in the form of urea fertilizer which is lower than the magnetic susceptibility value of soil samples that have not been used as agricultural land. Two coffee plantations in Danau Kembar District, Solok Regency had different magnetic susceptibility values even though they used the same type of coffee [5].

Grain size and type of magnetic domain affect the fertility of oil palm plantations. The stable domain causes the magnetic mineral properties of the soil to be stable so that the plantation soil becomes fertile [15]. The Value of soil magnetic susceptibility on rice fields was lower than on vacant land in Gunung Talang District, Solok Regency. This is because the vacant land has an excess of Fe. The higher the Fe content in the soil, the higher the magnetic susceptibility value [16].

Based on the problems above, it is necessary to conduct further research on Paddy soils with the aim of looking at the differences in the magnetic susceptibility values of Paddy soils due to the use of chemical fertilizers in Surantih, Pesisir Selatan Regency. Research on soil fertility with the same land planted with the same seeds but different treatments in terms of the magnetic susceptibility value of the land has not been carried out. Where, the land used is one of them given chemical fertilizers and not given chemical fertilizers.

2. Method

This research is an experimental research, using rock magnetism method with magnetic susceptibility parameters. This Research lasted for 47 days starting from January 31 to March 18 2022. Sampling was Carried out 2 times. The first sample was taken January 31 and the second sample was taken February 27 2022 in Surantih Pesisir Selatan District. Sampling Locations in this study can be seen in Figure 1.

Based on the geological map, Pesisir Selatan District has several geological formations among them The Ombilin formation are quartz rock containing mica, arkose inserts, clay shale (clay), quartz and coal conglomerates. And then phyllite and shale of the kuantan formation, shale and slate inserts of slate, siltstone, chert and lava flows. Pesisir Selatan District has Limestone granite composed of leuco-granite to quartz menzonite, generally phaneritic-forliritic structure. The last, Brani formation, conglomerate with sand and pumice inserts. Soil type in Pesisir Selatan District consist of organosol. Alluvial, regosol, andosol and latosol soil [1]. This research begins with land preparation, sampling to the data analysis stage. The stage of making the rice nursery begins with forming the paddy soils into 2 parts (Figure 1) which consists of paddy soil that uses chemical fertilizers (A) and Paddy soils that

do not use chemical fertilizers (B). After making the nursery, samples were taken using a shovel that was plugged into the soil. The sample is then put into a plastic sample or ziplock plastic.

In Figure 2 can be seen that the samples taken were samples of paddy soils soil before sowing rice seeds that would not use chemical fertilizers (Figure 2a) and Paddy soils before sowing rice seeds that would use chemical fertilizers (Figure 2b). Samples were taken from rice fields located in the Surantih area, Pesisir Selatan Regency. The sample in this study was determined using a simple random sampling (SRS) technique with 12 research points (Figure 3)[17].

In Figure 3 it's shown that the distance between sampling points is irregular because the simple random soil sampling is carried out on land with a flat topography with the same soil type, which is estimated to have homogeneous soil physical properties or the difference is not significant.

The finished samples were dried at room temperature for 3 to 4 days. Drying is done so that the water vapor contained in the sample is reduced. The dried samples were then crushed using a mortar. The soil sample was then put into a holder with a diameter of 2.4 cm and a height of 2.3 cm until it was completely filled.

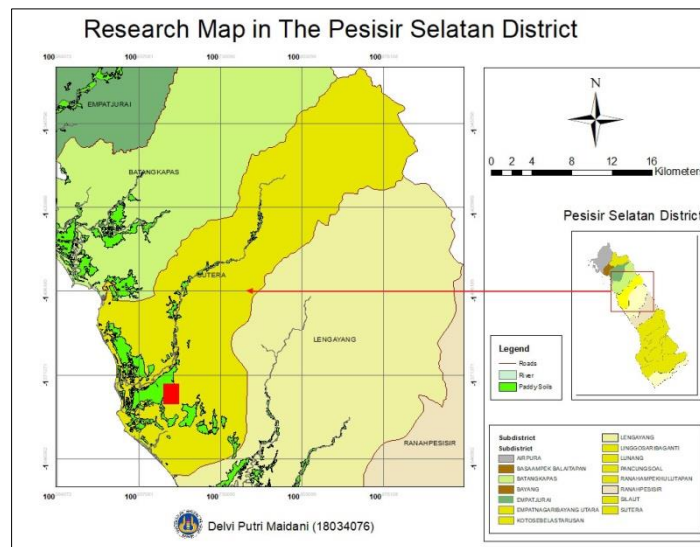


Figure 1. Map showing sampling locations of paddy soils (red rectangular) in the Pesisir Selatan district.

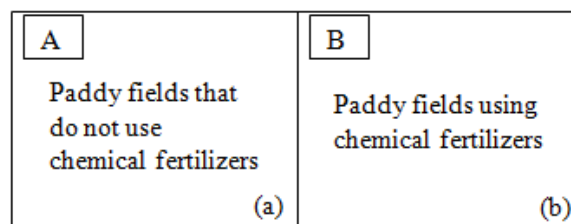


Figure 2. Plan of rice seedbed (a) paddy soils that does not use chemical fertilizer (A) and (b) paddy soil that uses chemical fertilizer (B).

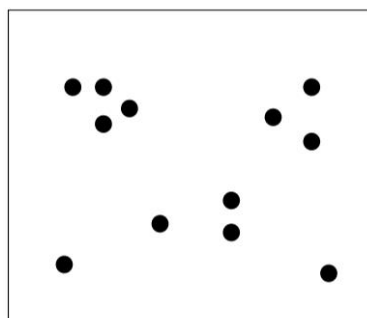


Figure 3. Sample of paddy soil sampling by simple random sampling (SRS).

After completing the sampling and initial sample preparation before planting rice seeds and applying chemical fertilizers. The Paddy soils are then planted or sprinkled with rice seeds with type IR 66. This type of rice seed has many advantages including resistance to pests and diseases, both planted in irrigated fields and not easy to fall. IR-66 variety is one of the varieties which is most widely grown in West Sumatra because the taste of rice is delicious and the selling price of grain and rice is higher [18]. If the rice seedlings are 6 days old, chemical fertilizers are given until the seeds are 20 days old. Giving chemical fertilizers (Urea, KCL and Phonska) to make more and greener tillers of rice seeds in a duration of 14 days. After the seedlings were planted and given chemical fertilizers, the samples were taken again and prepared according to the previous steps. Then measure the magnetic susceptibility value at the Geophysics Laboratory, Padang State University using a Bartington Magnetic Susceptibility Meter sensor type B (MS2B).

3. Result and Discussion

Measurement of the magnetic susceptibility value of paddy soils using a Bartington Magnetic Susceptibility Meter sensor type B (MS2B) [19][20]. Measurement was carried out on 2 samples of paddy soils, where there were samples of paddy soils that used chemical fertilizers and there were samples of paddy soils that did not use chemical fertilizers. The measurement results can be seen as follows:

3.1. Magnetic Susceptibility Value of Paddy Soil

a) Paddy Soil using chemical fertilizers

The value of magnetic susceptibility of rice soil samples before planting rice seeds that will use chemical fertilizers is 12 samples (TSADP). Whereas the magnetic susceptibility value of paddy soil samples after planting rice seeds using chemical fertilizers was 12 samples (TSFDP). The average value of the magnetic susceptibility of paddy soil can be seen in Table 1.

Table 1. The average value of the magnetic susceptibility of paddy soils before and after planting rice seeds that will use chemical fertilizers.

No.	Sample Name	Average Magnetic susceptibility value ($10^{-8} \text{m}^3/\text{kg}$)		χ_{fd}	$\chi_{fd}(\%)$
		Low Field (χ_{lf})	High Field (χ_{hf})		
1.	TSADP_01	121.7	120.6	91	0.91
2.	TSADP_02	100.7	99.8	89	0.89
3.	TSADP_03	124.9	123.3	123	1.23
4.	TSADP_04	129.9	129.0	68	0.68
5.	TSADP_05	92.4	91.3	126	1.26
6.	TSADP_06	104.3	103.2	114	1.14
7.	TSADP_07	101.6	100.4	125	1.25
8.	TSADP_08	158.1	156.3	109	1.09
9.	TSADP_09	110.6	109.7	78	0.78
10.	TSADP_10	127.6	126.3	97	0.97
11.	TSADP_11	151.8	150.8	65	0.65
12.	TSADP_12	90.7	89.8	92	0.92
13.	TSFDP_01	118.6	117.1	131	1.31
14.	TSFDP_02	117.3	115.1	184	1.84
15.	TSFDP_03	124.6	123.3	110	1.10
16.	TSFDP_04	113.7	111.8	167	1.67
17.	TSFDP_05	116.7	115.3	120	1.20
18.	TSFDP_06	122.3	120.6	141	1.41
19.	TSFDP_07	117.0	115.5	126	1.26
20.	TSFDP_08	103.8	103.0	71	0.71
21.	TSFDP_09	118.1	116.6	131	1.31
22.	TSFDP_10	122.6	121.5	95	0.95
23.	TSFDP_11	115.5	114.7	67	0.67
24.	TSFDP_12	112.0	111.1	79	0.79

In Table 1, it can be seen that the sample of paddy soil before planting rice seeds (TSADP : Black) had the greatest magnetic susceptibility value in the sample TSADP_08 and the sample of paddy soil which had the smallest magnetic susceptibility value in the sample TSADP_12. The smallest frequency dependent magnetic susceptibility $\chi_{fd}(\%)$ is found in sample TSADP_11 and the largest frequency dependent magnetic susceptibility $\chi_{fd}(\%)$ is found in sample TSADP_05. Then, the paddy soil after planting rice seeds (TSFTDP : Red) had the greatest magnetic susceptibility value in the TSFDP_03 sample and the paddy soil sample which had the smallest magnetic susceptibility value in the TSFDP_08 sample. The smallest frequency dependent magnetic susceptibility $\chi_{fd}(\%)$ is found in the TSFDP_11 and the largest frequency dependent magnetic susceptibility $\chi_{fd}(\%)$ is found in the TSFDP_02.

The magnetic susceptibility value of paddy soils using chemical fertilizers partially decreased the magnetic susceptibility value and partially increased the magnetic susceptibility value. This happens because fertilization can cause the remaining certain elements and cause some other elements to be excessive or less [7].

Paddy soil before planting rice seeds before planting rice seeds has a magnetic susceptibility value of 82.8×10^{-8} m³/kg up to 161.9×10^{-8} m³/kg, while paddy soil after planting rice seeds after planting rice seeds has The magnetic susceptibility value is 91.0×10^{-8} m³/kg up to 126.8×10^{-8} m³/kg.

b) Paddy Soil not using chemical fertilizers

The value of magnetic susceptibility of rice soil samples before planting rice seeds that will not use chemical fertilizers is 12 samples (TSATDP). Whereas The magnetic susceptibility value of paddy soil samples after planting rice seeds not using chemical fertilizers was 12 samples (TSFTDP). The average value of the magnetic susceptibility of paddy soil can be seen in Table 2.

Table 2 shows that the sample of paddy soils before planting rice seeds (TSTDP : Orange) had the greatest magnetic susceptibility value in the TSATDP_03 sample and the smallest magnetic susceptibility value in the TSATDP_02 sample. The value of frequency dependent magnetic susceptibility $\chi_{fd}(\%)$ is highest in sample TSATDP_09 and the value of frequency dependent magnetic susceptibility $\chi_{fd}(\%)$ is smallest in sample TSATDP_01. Meanwhile, the paddy soil sample after being planted with rice seeds (TSFTDP : Blue) had the greatest magnetic susceptibility value in the TSFTDP_05 sample and the smallest magnetic susceptibility value in the TSFTDP_11 sample. The smallest frequency dependent magnetic susceptibility $\chi_{fd}(\%)$ is found in the TSFTDP_09 sample and the largest frequency dependent magnetic susceptibility $\chi_{fd}(\%)$ is found in the TSFTDP_08 sample.

The magnetic susceptibility value of paddy soils that did not use chemical fertilizers experienced a significant decrease in the magnetic susceptibility value with an average of 59.5×10^{-8} m³/kg. It is also seen in the statistical test that the susceptibility value of the sample has a non-homogeneous variance. This is due to the high absorption of Fe from plants in rice fields that do not use chemical fertilizers and the absence of additional macro elements such as N, P, K and make the soil loose structure [5] [7]. Paddy soil before planting seeds has a magnetic susceptibility value of 101.6×10^{-8} m³/kg to 218.5×10^{-8} m³/kg, while paddy soil after planting rice seeds has a magnetic susceptibility value of 66.0×10^{-8} m³/kg up to 93.8×10^{-8} m³/kg.

3.2. Relationship between magnetic susceptibility and pH of paddy soil

Based on the research that has been done, it is obtained that the value of Low field magnetic susceptibility (χ_{lf}) and the average pH of paddy soil are as shown in Table 3. In paddy soil before planting rice seeds that will not use chemical fertilizers (TSATDP), paddy soil before planting rice seeds which will use chemical fertilizers (TSADP), rice fields after planting rice seeds that do not use chemical fertilizers (TSFTDP), rice fields after planting rice seeds using chemical fertilizers (TSFDP). In this case, the average value of the magnetic susceptibility of paddy soil and the average pH of paddy soil are used. because, the research was carried out in stages by taking samples before and after planting rice seedlings. In order not to be mistaken and to carry out accurate research, 4 point values of magnetic susceptibility and pH of paddy soil were taken.

Table 3 shows The pH of the paddy soil before planting rice seeds that will use chemical fertilizers and those that will not use chemical fertilizers is the same, namely 6.8. While the paddy soil after planting rice seeds has a different pH value. Rice field soil that does not use chemical fertilizers

(TSFTDP) has a pH of 5.7 while rice fields that use chemical fertilizers (TSFDP) has a pH of 6.3. Based on Table 3, the relationship between the values of Low field magnetic susceptibility (χ_{lf}) and the pH of the average paddy soil is shown in Figure 3.

Figure 4 shows the correlation between the pH of the paddy soils and the magnetic susceptibility value of the paddy soils. The Low field magnetic susceptibility (χ_{lf}) is small or low, namely 0.081, meaning that the pH of the paddy soil has no significant effect on the magnetic susceptibility value obtained. The figure shows that the pH of the paddy soil before planting rice seeds that will use chemical fertilizers (TSADP: black dots) and those that do not use chemical fertilizers (TSTDTP: orange dots) is the same, namely 6.8. Meanwhile, paddy fields after planting rice seeds have different pH values. Rice fields that do not use chemical fertilizers (TSFTDP: blue dots) have a pH of 5.7 while those that use chemical fertilizers (TSFDP: red dots) have a pH of 6.3.

In general, the magnetic susceptibility value of paddy soil increases with increasing pH value [21][22]. Soil acidity is thought to have an effect on the abundance of magnetic minerals, the more acidic, the less magnetic minerals and vice versa. Magnetic minerals will affect the value of magnetic susceptibility [23].

Fertile soil has an optimum pH value of 6-7[11]. Based on Table 6 for paddy soil using chemical fertilizers having a soil pH of 6.3 – 6.8, it was also found that a stable magnetic susceptibility value of 91.0×10^{-8} m³/kg to 126.8×10^{-8} m³/kg was considered good for farming [24][14]. Meanwhile, paddy soils that do not use chemical fertilizers have a soil pH of 5.7 – 6.8. This shows that the paddy soils that do not use chemical fertilizers have a decrease in the pH value and also a decrease in the magnetic susceptibility value, which is indicated by the average magnetic susceptibility value of 66.0×10^{-8} m³/kg to 93.8×10^{-8} m³/kg. So it can be said that the use of chemical fertilizers on paddy soils in a short time and in accordance with proper fertilization guidelines can make the soil pH not decrease to acid or alkaline.

3.3. Effect of soil pH on seed length

The effect of pH on the length of seeds that use chemical fertilizers and those that do not use chemical fertilizers can be seen as shown in Figure 5. Measurements started from the first day of sampling 31 January 2022 to 27 February 2022. The final pH value of paddy soils using chemical fertilizers was 6.3 with seed length 42 cm. while the paddy soils that did not use chemical fertilizers obtained a final pH value of 5.7 and a seed length of 35 cm.

Can be seen in figure 5 that the correlation between Paddy soil pH and seed length using chemical fertilizers (Fig 5a) is quite high, 0.828, meaning that the soil pH greatly affects seed length. High soil pH makes seed length also fast while low soil pH makes seed length also slow. A good soil pH for plants is 6-7 or close to neutral pH. But should not exceed pH 7, the soil will be alkaline. Meanwhile, the correlation between lowland soil pH and seed length that did not use chemical fertilizers (Fig 5b) was also quite high at 0.691 but not as high as those using chemical fertilizers, meaning that the pH of paddy soil greatly affected seed length.

The soil acidity desired by rice plants is between pH 4.0-7.0. In lowland rice, inundation will change the soil pH to neutral (7.0). In principle, calcareous soil with a pH of 8.1-8.2 does not damage rice plants. Due to inundation, the paddy soil has a reduction layer that does not contain oxygen and the pH of the paddy soil is usually close to neutral [23]. A soil pH close to neutral (pH=7) can promote longer, greener seed yields. an increase in pH increases the weight of root nodules at the end of the vegetative period of the plant [25].

This is because the level of acidity (pH) of the soil can affect the activity of several types of bacteria in the soil, thereby affecting the number of root nodules formed [26].

In the research conducted, it can be seen that the pH of paddy soils is not much different from using chemical fertilizers with those not using chemical fertilizers. The length of the seeds of paddy soils that used chemical fertilizers was 42 cm while those that did not use chemical fertilizers had a seed length of 35 cm.

4. Conclusion

The paddy soil before and after planting rice seeds using chemical fertilizers had a stable magnetic susceptibility value from $117,8 \times 10^{-8}$ m³/kg to $116,9 \times 10^{-8}$ m³/kg. This is due to the reaction between mineral fertilizers and soil minerals. Meanwhile, the paddy soil before and after planting rice

seeds that did not use chemical fertilizers decreased the magnetic susceptibility value quite far from $145,6 \times 10^{-8} \text{ m}^3/\text{kg}$ to $86 \times 10^{-8} \text{ m}^3/\text{kg}$. This is due to the absence of additional minerals in the paddy soil such as chemical fertilizers. Paddy soil that use chemical fertilizers have a value of $\chi_{fd}(\%)1.18\%$ with a pH of 6.3 close to normal and a seed length of 42 cm, meaning that the paddy soil are fertile and good for farming. Meanwhile, paddy soil that do not use chemical fertilizers have a value of $\chi_{fd}(\%)1.23\%$ with a pH of 5.7 and a seed length of 35 cm, meaning that paddy soil that do not use chemical fertilizers are less fertile than paddy soil that use chemical fertilizers.

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