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Study of Several Relationship of Fertility Parameters on Rice Production of Ciherang Variety on Regosol Soils in The Southern Slopes of Merapi, Yogyakarta, Indonesia

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Abstract

One of the volcanoes known as the most active mountain in the world is Mount Merapi. The impact of the Merapi eruption can lead to the addition of volcanic material whose deposits can fertilize the soil. This study aims to determine the relationship of several fertility parameters to the production of Ciherang variety on regosol soil in the Southern Slopes of Merapi, Yogyakarta, Indonesia. Observations were made by taking soil fertility samples as many as 37 demonstration plots using the stratified purposive sampling method. Statistical data from the relationship between fertility parameters on rice production were processed using simple linear regression. From this simple linear regression, we can find parameters that have a significant effect and non-significant effects on rice production and also information on fertility parameters in the form available in the soil with a greater effect than those in the total form. The results showed that phosphorus in the total form has a value of R^2 = 0.3229 to DGH, whereas phosphorus in the available form (Bray 1) has a value of R^2 = 0.7142 to plant production (DGH). Potassium in the total form has a value of R^2 = 0.1124 to GKP, while the potassium in the form available (Morgan K_2O) has a value of R^2 = 0.3233 to DGH. Cation Exchange Capacity (CEC) and Base Saturation (BS) each have a value of 0.3651 and 0.5758 for plant production (DGH). C-org and Si each have R^2 = 0.4639 and 0.324 values for crop production (DGH). R^2 values close to 0.5 in the cross-section data can be said to be high.

Keywords: Merapi, soil fertility, crop production, linear regression, regosol soil

I. INTRODUCTION

Soil is one part of environmental problems, in addition to water, air, flora, and fauna. Stockholm Declaration states that it is a human responsibility to preserve the environment and natural resources in it (including soil), both renewable and non-renewable, so that the results can be enjoyed by future generations (Sohn, 1973). Fertile soil, as part of nature and the environment, is a dream for living

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things to be able to live their lives. The fertile soil can be produced from various natural life cycle processes, one of which is from volcanic eruption deposits.

This study aims to determine the relationship of several fertility parameters to the production of Ciherang variety on regosol soil on the Southern Slopes of Merapi, Yogyakarta. The relationship between fertility parameters on rice production was obtained by simple linear regression. From simple linear regression, we can find parameters that have significant or non-significant effects. This influence can be seen from R^2. From the simple linear regression, it can also be obtained information that the fertility parameters in the form available in the soil have a greater (significant) effect than those in the total form.

II. LITERATURE REVIEW

One of the most active volcanoes in the world is Mount Merapi (110.442° E, 7.542° S). The distribution of diverse fertility on the southern slopes of Merapi is influenced by several factors, such as the distance of the location to the peak of Merapi, the direction of the wind, and the distance close to the river lip. The closer the area with the peak of Merapi, the more existing material is large, and the farther from the peak of Merapi, the more existing material is smaller (Gertisser et al., 2012).

In the study area located on the Southern Slopes of Merapi, the particles that contribute also are influenced by the direction of the wind. Areas close to the river mouth will also have different conditions for soil fertility. This is due to the addition of volcanic activity and also the refreshment of material from overflowing river water. With various considerations on the diversity of fertility in the study area, it is important to look at the relationship of several fertility parameters to rice production on the Southern Slopes of Merapi. The location of the Southern Slopes of Mount Merapi can be seen in Figure 1 below:

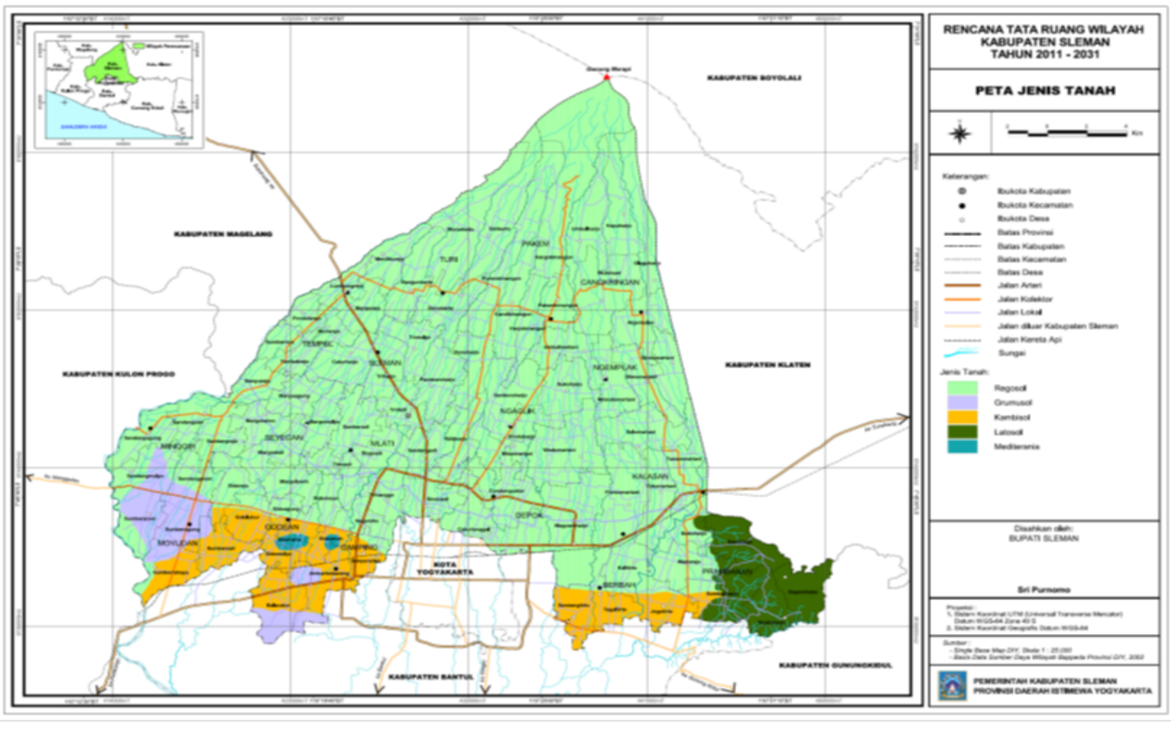


Figure 1. Map of the Southern Slopes of Mount Merapi

Soil derived from volcanic eruption material is called regosol soil. Regosol soil has fertile properties, has a rough soil texture, coarse grains, is sensitive to soil erosion, has a grayish color, is rich in nutrients, tends to lose, has the ability to absorb water that is high, and easily exposed to erosion (Hristov, 2014; Azmi et al., 2015).

Soil fertility in each area is very different, depending on various things. Sitorus et al. (2018) explain soil fertility is the ability of the soil to provide nutrients needed by plants to support their growth and reproduction. Soil fertility parameters that can be seen, for example, soil texture (soil grain size), organic minerals that are in the soil, soil moisture levels, soil air content, inorganic minerals (soil nutrients), soil water content, etc. (Cambardella & Karlen, 1999; Nandagawali, 2015).

Researches on fertility parameters for rice plants (*Oryza sativa* L) have been considerable. Some previous researchers who examined the relationship of fertility parameters to rice plants such as: (Adiningsih et al., 1989; Roder et al., 1995; Abdulrachman et al., 2000; Haefele et al., 2000; Rochayati & Adiningsih, 2002; Dobermann et al., 2003a; Dobermann et al., 2003b; Rahman & Parkinson, 2007; Abe et al., 2010; Chen et al., 2012; Tabi et al., 2013; Talpur et al., 2013; Khaki et al., 2017; Sulakhudin et al., 2017; Julianto et al., 2018; and Putri et al., 2019).

III. RESEARCH METHODOLOGY

III.1.Research area

The study was conducted on the Southern Slopes of Merapi, known as soil fertility (regosol soil type). The main basis used in this study is paddy fields (at least half technical water) in the land map unit and its area.

III.2. Samples and research methods

The samples in this study were 37 demonstration plots spread on the Southern Slopes of Merapi. A total of 37 demonstration plots were planted with rice (Oryza sativa L) of the Ciherang variety because this species was considered normal to grow on regosol soil on the South Slope of Merapi. Observations were made by sampling soil fertility at points (37 demonstration plots), which were determined using the stratified purposive sampling method.

III.3. Data analysis

The soil samples then are analyzed in the laboratory to determine the status of the day, which includes: C-organic, N-total, H_2O pH, pH KCl, P_2O_5, K_2O, P-Bray, Morgan K_2O, Ca, Mg, K, Na, Ca-total, Mg-total, Cation Exchange Capacity (CEC), Si, Texture, Base Saturation (BS), P-Retention, and P-Olsen. The component of rice production observed in this study was dry grain harvest (DGH).

Statistical data in this study were processed using simple regression analysis. After processing, then a correlation with soil fertility parameters is carried out as an axis (X) against crop production (DGH) as the axis (Y). In a coherent analysis of time, usually, all variables will increase over time, so the value of R^2 will tend to be high. In the analysis using cross-section data, the value of R^2 will tend to below.

IV. FINDING AND DISCUSSION

IV.1. Phosphorus is needed to improve plant quality

Phosphate availability is rare earth exceeds 0.01% of total P. Most forms of phosphate are bound by colloidal soils that are not available to plants. Soils with low organic content having organic phosphate content vary depending on the type of soil (Islamiati & Zulaika, 2015).

The results showed that phosphorus in the total form had a value of $R^2 = 0.14$ to GKP2, whereas phosphorus in the available form (Bray 1) had a value of $R^2 = 0.7142$ to GKP2 (see Figure 2). This means that the variation in the fluctuations of phosphorus in the available form has a greater effect on production (DGH) than in the total form. Retention P in the study area has a value of R2 = 0.3229. It can be said that with the increasing number of P being bound by land, rice production will decrease further. As a nutrient, phosphorus is needed by rice plants in the form of Adenosine Triphosphate (ATP) and Adenosine Diphosphate (ADP), which play a major role in improving the quality of these plants so as to increase productivity.

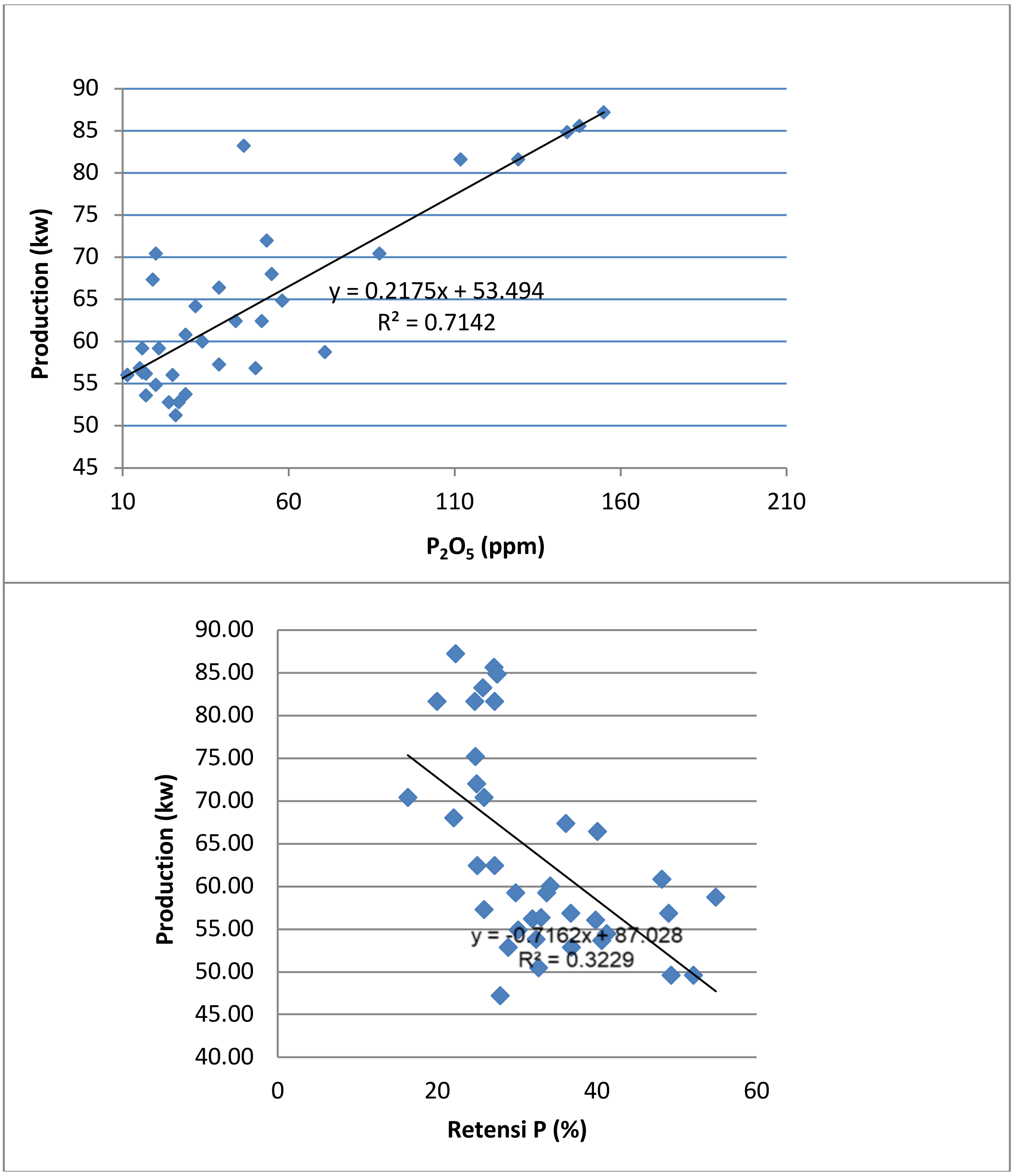


Figure 2. Relationship between phosphorus and rice production (DGH)

IV.3. Potassium in the form available has a greater effect.

Potassium (K) is an essential nutrient used in almost all processes to support plant life. Potassium has one valence and is absorbed in the form of K^+ ions. Potassium is classified as a mobile element in plants, both in cells, in plant tissues, and in xylem and phloem. Potassium is abundant in the cytoplasm (Damanik et al., 2010).

The results of this study indicate that the total form of potassium has a value of $R^2 = 0.1124$ to DGH, while the available form of potassium (Morgan K_2O) has a value of $R^2 = 0.3233$ to DGH (see Figure 3). This means that the variation in the rise and fall of potassium in the form available has a greater effect on rice production (DGH) than in the total form. As a nutrient element, potassium is useful for the development of plant roots, making plant seeds denser and fuller, and making plants more resistant to pests and diseases.

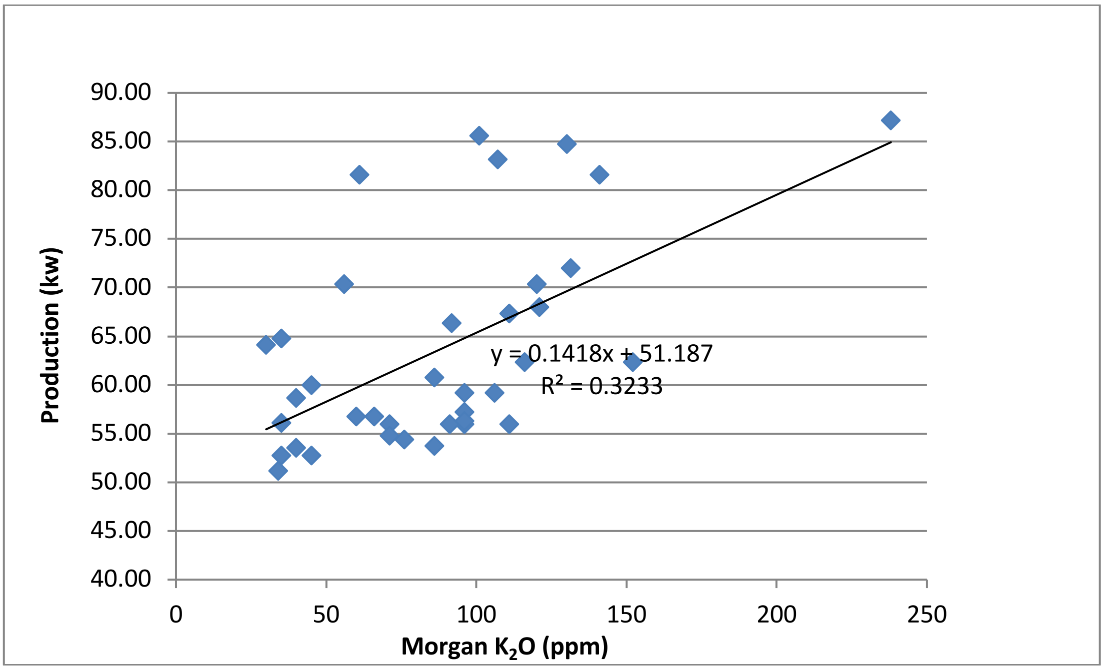


Figure 3. Relationship between potassium and rice production (DGH)

The variation in the ups and downs of the KPK and KB is equally influential.

Cation Exchange Capacity (CEC) in soil science is defined as the ability of the soil to absorb and exchange or release it back into the soil solution (Brady & Weil, 2008). In the soil, components that have a charge are clays and soil organic matter (organic compounds). Practically, cation exchange is very important in soil physics, soil chemistry, soil fertility, nutrient retention in soil, nutrient uptake by plants, fertilization, and calcification.

Base Saturation (BS) is the percentage of total Cation Exchange Capacity (CEC) occupied by alkaline cations such as potassium, calcium, magnesium, and sodium. BS values are closely related to pH and soil fertility. The acidity will decrease, and fertility will increase with increasing BS. The cation release rate depends on the level of saturation of the soil base. Saturation of soil base ranges from 50% - 80% classified as having moderate fertility and is said to be infertile if it is less than 50% (Tan, 1991).

In Figure 4 from this research shows that CEC has a value of R^2 = 0.3651 against DGH, while BS has a value of R^2 = 0.5758 against DGH. This means that the variation in the ups and downs of the CEC and BS is as large as the effect on rice production (DGH). CEC has a smaller value R^2; this is related to the sand fraction, which dominates the study area. The value of R^2 approaches 0.5 in the cross-section data, including height (see Figure 4).

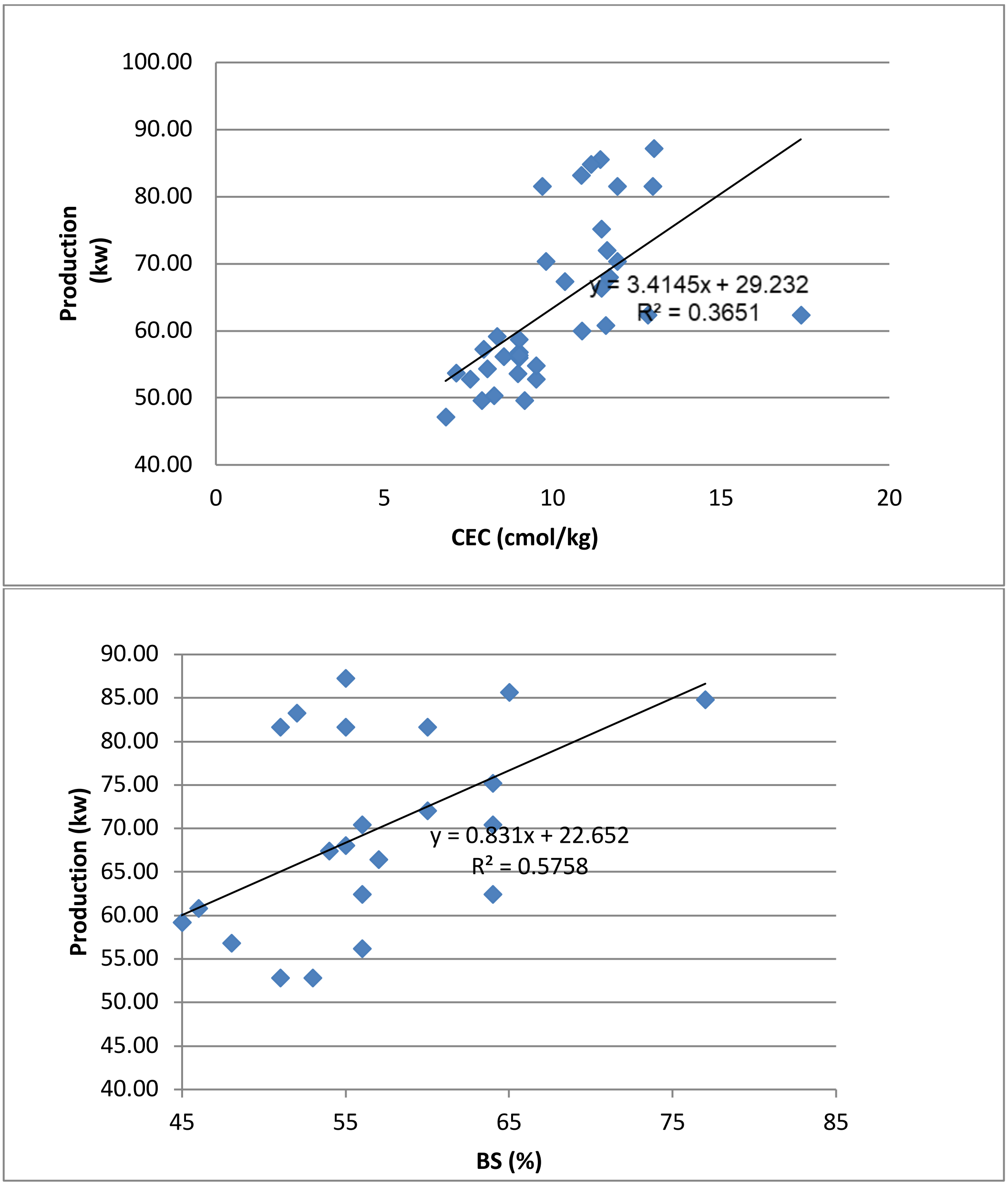


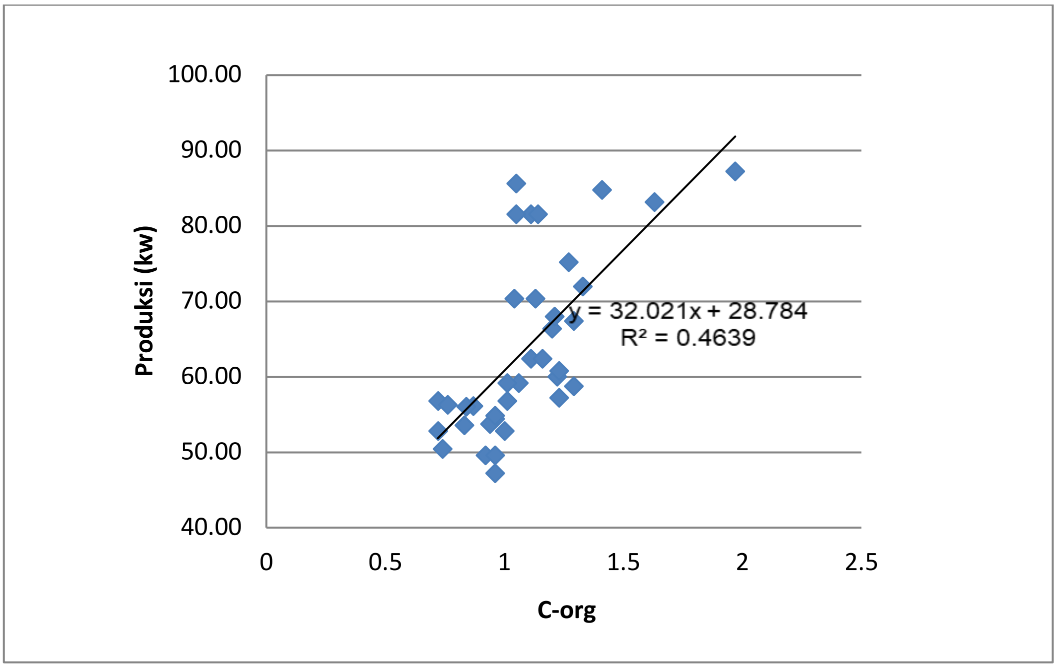
Figure 4. Relationship between CEC, BS and rice production (DGH)

IV.4. Effect of C-organic and Si in the soil

C-organic content states the number of organic compounds as a source of carbon elements contained in the soil, including the fraction of light organic matter, biomass microorganisms, organic matter dissolved in water, and stable organic matter or humus (Surya & Suyono, 2013). C-organic levels tend to decrease as soil depth increases because organic material is only applied or falls on the ground so that the organic material accumulates in the topsoil layer and partially is washed into deeper layers or subsoil (Sipahutar et al., 2014).

The silica (Si) element is an important nutrient for some food crops, including rice, which is a beneficial element (Epstein, 1999). This element has long been known to be absorbed by large quantities of plants, especially Si accumulator plants. Some of the accumulator plants of Si are the families Gramineae and Cyperaceae. Unlike nutrients N, P, and K, the role of Si as a nutrient has not received attention. The low availability of Si in paddy fields in the tropics is one of the causes of a decrease in rice productivity (Savant et al., 1997a & 1997b).

Figure 5 of this study shows that the C-org content with R^2 = 0.4639 did not contribute to large nitrogen content. It is suspected that the C-org content does not originate from legumes which are contributors to organic N. In addition, the nature of N itself, which quickly disappears in the soil is the cause, both lost through the air through the process of volatilization, as well as lost through the soil through leaching mechanisms (leaching) because the dominant soil texture is sand. Figure 5 can also be seen in the Si content with the value R^2 = 0.324. This can be interpreted that Si, which increases in the soil, negatively affects the GKP. Its influence, among others, can reduce crop production; even if it is too excessive can poison plants, so it is not suitable for plant growth media.



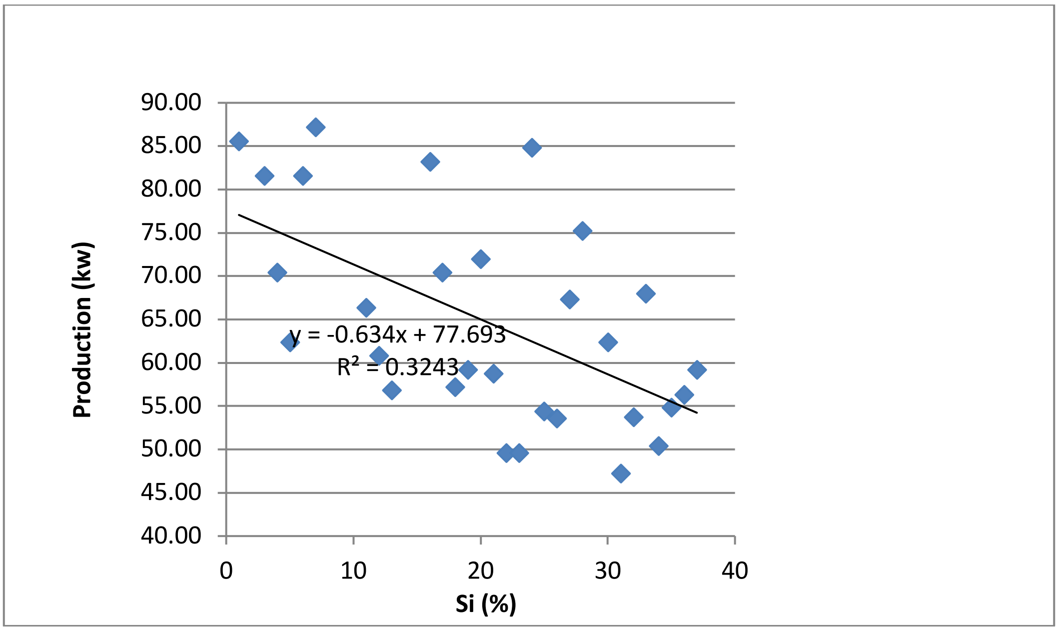


Figure 5. Relationship between C-org, and Si and rice production (DGH)

V. CONCLUSION AND FURTHER RESEARCH

The soil is one of the most important parts of living things on earth because its existence can support the survival of humans and other living things. Fertile soil is able to produce important nutrients for plant growth in agriculture, such as rice, vegetables, crops, etc. which can be useful for improving human health and well-being on this earth.

The results showed that phosphorus in the total form has a value of R^2 = 0.3229 to DGH, whereas phosphorus in the available form (Bray 1) has a value of R^2 = 0.7142 to plant production (DGH). Retention P in the study area has a value of R^2 = 0.3229. This shows that with the increasing number of P bound by land, production will decrease further. Potassium in the total form has a value of R^2 = 0.1124 to DGH, while the potassium in the form available (Morgan K_2O) has a value of R^2 = 0.3233 to DGH. CEC and BS each have a value of 0.3651 and 0.5758 for plant production (DGH). C-org and Si each have R^2 = 0.4639 and 0.324 values for crop production (DGH). R^2 values close to 0.5 in the cross-section data can be said to be high.

Like most studies, this study has several limitations. *First*, existing research samples have not yet reached the overall condition of regosol soil on the South Slope of Merapi (only 37 demonstration plots). *Second*, uncertain weather changes, rain, and heat are not taken into account in this study. The relationship between fertility parameters for rice production may be supplemented by a validation test of fertility models in further studies.

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