BioLink : Jurnal Biologi Lingkungan, Industri dan Kesehatan, Vol. 9 (2) Feb (2023)
ISSN: 2356- 458X (print) ISSN: 2597-5269 (online)
DOI: 10.31289/biolink.v9i2.8178

BioLink
Jurnal Biologi Lingkungan, Industri, Kesehatan

Available online http://ojs.uma.ac.id/index.php/biolink

SOIL QUALITY IN ORGANIC AGRICULTURAL LAND: STUDY OF CHEMICAL ANALYSIS AND SOIL MICROBIOLOGY

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Submited : 03-01-2023; Reviewed : 03-01-2023; Accepted : 14-02-2023

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Abstract

Increased public awareness for a healthy diet must be balanced with successful cultivation. Organic farming system is the right choice since it leaves all non-organic components. This study aims to identify the chemical and microbiological properties of agricultural soils that apply organic systems located in Batang Buluh Village, Pematang Johar, Deli Serdang Regency, North Sumatra. Chemical analysis was carried out at Socfindo Laboratory in Medan, including testing the pH of H2O, total P and K, C Organic, N Kjehldahl, and CEC (Cation Exchange Capacity). Soil microbiological tests were carried out at Medan Regional Health Lab including gram staining tests and biochemical tests. The results of chemical analysis from the analysis of pH H2O, P and total K, Organic C, N Kjehldahl, and CEC (Cation Exchange Capacity) at the edges and middle each obtained that was pH 5 -6, soil total P content was 0.0260% up to 0.450%, available K analysis, namely 0.200% and 0.210%, organic C content obtained results of 0.970% and 0.630%, N content using the KJehldahl method was 0.150% and 0.090%, and CEC obtained results of 14.330 me/100 and 10.090 me/100 g. Related species of Bacillus contained in the soil were Gram-positive, rod-shaped, spore-forming, aerobic or facultative anaerobic, motile bacteria with peritrichous flagella.

Keywords: pH H2O, N Kjeldahl; Organic Agriculture; Gram Stain Test; Biochemistry Test

How to Cite: Hutasuhut, M.A., Febriani, H., & Widiarti, L. (2023). Soil Quality In Organic Agricultural Land: Study Of Chemical Analysis And Soil Microbiology, *BioLink: Jurnal Biologi Lingkungan, Industri dan Kesehatan*, 9 (2): 209-218.

INTRODUCTION

At the end of 2017, the total hectares of organic farmland globally was 69.8 million. It only accounts for a meager 1.4% of the world's total agricultural land, however the increase is staggering: 20% the largest growth ever recorded compared to 2016 (Pu et al., 2020).

Soil is the main component of the ecosystem which plays an important role in supporting plant growth and development. It supplies water and essential nutrients needed by plants to ensure their physiological processes (Hindersah et al., 2018). It concluded that organic farming could provide benefits to human health and the environment, and promote a more compassionate treatment of animals (Gomiero, 2018).

One of the requirements of precision agriculture is soil analysis to establish the fertilizer recommendations. Fertilizer recommendations are usually for nitrogen (N), phosphorus (P), and potassium (K). The application of inorganic fertilizers N, P, and K continuously with high doses results in nutrient imbalances and environmental pollution. Nutrient imbalances can be avoided if the fertilization dose refers to balanced fertilization based on an analysis of soil nutrients (Hartono et al., 2021).

Organic farm production and sales of organic food have grown rapidly, and agricultural extension services have the opportunity to develop and deliver organic education programs for organic farmers to ensure the information is available to all farmers,

This article provides information on soil quality on organic farming land in Batang Buluh Pematang Johar Village, Labuhan Deli District, Deli Serdang Regency in terms of soil chemical properties including analysis of soil pH, nitrogen content, phosphorus, potassium, cation exchange capacity, and organic C. Compared to conventional products, the organic products are richer in several beneficial compounds.

Recently, evidence has accumulated that yields under organic management are on average, 19%-25% lower than under conventional management. (Seufert, 2018). Organic fertilizers can improve soil physics, chemistry and biology, so that agricultural sustainability can be maintained (Syamsiyah et al., 2017). Therefore the researcher was interested in analyzing the chemical content of soil in organic agricultural land, including testing the pH of H_2O, total P and K, , C Organic, N Kjehldahl, and Cation exchange. Cap.

For large numbers of people, soil pH is only significant for soil chemistry and fertility. Nevertheless, the introduction of soil functions beyond the supply of plant nutrients and the role of soil as a medium for plant growth requires the study of soil and its properties in relation to broader ecosystem functions through a multidisciplinary approach (Neina, 2019).

In soil, the cations are bound to clay and organic matter and can be replaced by other cations so that they can be exchanged. Percent nutrient saturation refers to a measure or estimate of the percentage of soil CEC occupied by a particular nutrient (nutrient saturation).

Management of potassium and other important nutrients is key to achieving a balanced fertility program. (Mbuvi et al., 2013). Nitrogen is an important part in the formation of chlorophyll, protoplasm, proteins, and nucleic acids. This element has an important role in the growth and development of all living tissues (Zakiyah et al., 2019).

Phosphorus is the second most important plant nutrient after Nitrogen. It is an essential macronutrient that plays a significant role in all plant biochemical processes such as photosynthesis, respiration, energy storage, transfer, cell division, cell enlargement and nitrogen fixation (Muindi, 2019).

Soil microbial components play an important role in keeping soil alive and functional, carrying out several indispensable functions such as soil formation, decomposition of dead and decaying organic matter, macro and micronutrient cycling and removal/transformation of toxic chemicals into non-toxic forms.

Based on the description of the importance of chemical and microbiological analysis of soil, the researcher would like to examine the quality of the soil in organic land which is hoped that further research will be useful in studying the manufacture of fertilizers and optimal soil conditions needed for organic farming in order to obtain the maximum results.

RESEARCH METHODS

The research was conducted in Pematang Johar Village, Deli Serdang Regency, North Sumatra. This village has more than 90% conventional agricultural land, and less than 10% organic agricultural land. Testing of soil chemical properties was carried out at Socfin Indonesia (Socfindo) laboratory. Soil

microbiology testing was carried out at Medan Regional Health Laboratory (Labkesda).

Figure 1. Google Maps Research Site

Figure 2. The condition of the rice fields in the research site

The tools used in this study include digging tools such as earth drills, hoes, shovels; measuring devices such as tape measure and ruler; AAS instrument to measure total P and K levels; *Walkley and Black with Spectrometer* for organic C measurements; pH (pH H_2O) by means of electrometric; *Spectrophotometer* for measuring N levels; *Spectrophotometer* for analysis of *Cation Exchange Capacity*.

This research was initiated by directly observing the conditions of the research location and asking permission

from the rice field owner to take soil samples.

Soil sampling (5 sample points). Soil sampling using the sampling design at points 1, 2, 3, 4, and 5).

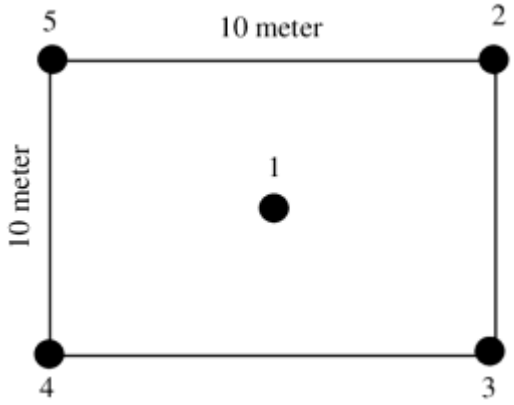

Figure 3. Soil Sampling Using Sampling Design at Points 1, 2, 3, 4, and 5)

Table 1. Sampling Based on Point and Depth in Each Agricultural System

Sample No	Depth	Sample name
1		Middle
2		Edge
3	20 – 40 cm	Edge
4		Edge
5		Edge

Disturbed soil samples were taken for testing the pH of H_2O, total P and K, , C Organic, N Kjehldahl, and Cation exchange. Cap.

Testing the chemical properties of the soil, namely testing the pH of H_2O, total P and K, , C Organic, N Kjehldahl, and Cation exchange. Cap. conducted at Socfin Indonesia laboratory (Socfindo). Testing of soil biological properties including microbiological tests on soil was carried out at Medan Regional Health Laboratory (Labkesda).

RESULTS AND DISCUSSION

Soil acidity has a very close relationship with soil fertility. The best soil acidity for plants to grow is neutral. The lower and higher than neutral will be worse for plant growth. This situation is a result of the availability of nutrients in the soil.

Table 2. Results of pH Analysis of Organic Agricultural Land at Depth of 20-40 cm from the Soil Surface.

Sample Name	pH(H2O)	Category
Edge organic	5,160	Sour
Middle organic	5,120	Sour

Most of the nutrients are in good availability at neutral soil pH. In this study, the average soil pH was acidic from 5.120 to 5.160. In paddy fields, farmers used fertilizers to increase soil pH (Kusumandari et al., 2018).

Results of N-Kjehldahl Analysis

Soil fertility is an important factor that determines the plant growth. Soil fertility is determined by the presence or absence of nutrients, namely macro nutrients and micro nutrients. Macronutrients like nitrogen (N), phosphorus (P) and potassium (K) together form the trio known as NPK. All these nutrients are accumulated by plants in their bodies in different concentrations.

Table 3. Results of N-Kjehldahl Analysis on Organic Agricultural Soil at Depth of 20-40 cm from the Soil Surface.

Sample Name	N-Kjehldahl (%)	Category
Edge organic	0.150	Low
Middle organic	0.090	Very low

The Kjeldahl method, which converts nitrogen into ammonium, is probably the most common method for analyzing substances for nitrogen (Kalambe, 2021). In this study, the N content obtained using the KJehldahl method was 0.150% at the edge of the rice field with low category and 0.090% in the middle of the rice field with very low category. It is since the organic agricultural land has not received a supply of organic fertilizer from the farmers so that the N content in the soil was very low.

Phosphorus Analysis Results

Phosphorus is the main plant essential macro nutrient needed for plant growth and development.

Table 4. Results of P Analysis on Organic Agricultural Soil at a Depth of 20-40 cm from the Soil Surface

Sample Name	P (%)	Category
Edge organic	0.260	Tall
Middle organic	0.450	Tall

The total P content of soil usually ranges from 0.02% to 0.15%. Most of the soil P is not available to plants and therefore is often a limiting nutrient in crop production. Currently, increasing environmental concerns and ever-decreasing P resources are driving the study of P cycling processes in soil-plant systems (Bhatt et al., 2019). Plants can take up dissolved phosphate species mainly in the form of H_2PO_4– and HPO_4^{2}– ions, this distribution is regulated by the pH of the solution and can be estimated from thermodynamic data (Balláné Kovács et al., 2021). Obtained high levels of P indicate the availability of high levels of P and the smooth cycle of P in the soil.

Cation Exchange Capacity Analysis Results (CEC)

Measurements of cation exchange capacity (CEC) show significant soil properties, particularly their ability to retain cations due to their mobility in the soil (Saidi, 2012).

Table 5. CEC Analysis Results Available on Organic Farming Soil at Depth of 20-40 cm from the Soil Surface

Sample Name	CEC (me/100g)	Category
Edge organic	14,330	Tall
Middle organic	10,090	Tall

The direct method for determining the CEC is based on the saturation of the exchange complex with the reference cation, followed by its extraction and analysis, whereas the indirect method for determining the CEC is based on the analysis and further amounts of exchangeable base extracted into the solution under pH control (Pujiastuti et al., 2021). From the research results, it was obtained that a high CEC value means its ability to hold the cations in the soil properly.

Potassium Analysis Results

The potassium content of ammonium acetate extract is considered as an estimate of the amount in the soil available for plant uptake (Mbuvi et al., 2013).

Table 6. Results of Analysis of Available K in Organic Agricultural Soil at a Depth of 20-40 cm from the Soil Surface.

Sample Name	K-Total (%)	Category
Edge organic	0.200	Low
Middle organic	0.210	Low

Potassium levels obtained from research on organic rice field soil in Batang Buluh Village, Pematang Johar Village, Deli Serdang Regency, North Sumatra ranged

from 0.200% with low levels. The low levels of K in the soil were caused by organic agricultural land that has not received organic fertilizer supplies from the farmers so that the level of K in the soil was low.

Organic C Analysis Results

Soil organic matter has an important role in sustainable soil management. Soil properties and processes in the soil are influenced by soil organic content include *bulk density*, temperature, structure, biological activity and nutrient availability. In addition, the organic matter content of the soil makes a positive contribution to the amount of C and N which can quickly mineralize into NH_4^+ to NO_3-.

Table 7. Results of Organic C Analysis Available in Organic Farmland Soil at a Depth of 20-40 cm from the Soil Surface

Sample Name	C-Organic (%)	Category
Edge organic	0.970	Tall
Middle organic	0.630	Tall

In Ermadani et al., (2018) conducted research on the Dynamics of the Soil Organic Carbon Fraction Under Different Land in the Wet Tropics, the results obtained were the distribution of the total soil organic C content (%) at a soil depth of 0-60 cm, which is around ±1.63% at a depth of 0 -15 cm, 1.36% at a depth of 15-30 cm and 1.04% at a depth of 30-60 cm.

The dynamics of soil organic C content was influenced by many factors, including the type of land use and management practices where decomposition and mineralization processes can reduce organic C content while increasing organic C content can occur by biomass input. Wet tropical rainforests are one of the main terrestrial C storage sources. However, the conversion of natural forest to agricultural land use leads to a reduction in soil organic C content overtime, due to the increased rate of mineralization stimulated by increased soil temperature -(Ermadani et al., 2018).

Results of Microbiological Analysis

Related species of *Bacillus* are Gram-positive, rod-shaped, spore-forming, aerobic or facultative anaerobic, motile bacteria with *peritrichous* flagella. From the observations, it was found that the bacteria contained in the soil in organic farming systems were *Bacillus sp*.

Related species of Bacillus widely predominate in various environments such as soils with varying environmental

conditions, fresh and salt water, plants and animals. These bacteria were one of the most important components of the soil microbial population, and they were often found in high abundance in harsh environments including desert soils, acid soils and saline-alkaline soils, indicating that the bacteria play an important role in these soil.

Table 8. Observation Results of Bacterial Biochemical Tests on Organic Farming Soil

Isolate Code	Gram stain		Biochemical Test			
	Form	Information	Test Catalase	Test Motility	Citrate Test	TSIA test
TO1	Bacil	Gram positive	+	+	+	A A
TO2	Cocobaccil	Gram positive	+	+	+	A A
TO3	Coccus	Gram positive	+	+	-	K/A

Survival of related species of Bacillus for a long time in different harsh environments was associated with the formation of resistant endospores that were resistant to harsh environmental conditions (Saxena et al., 2020).

CONCLUSION

Research on analysis of Soil chemistry on organic agricultural land in the village of Batang Buluh Village, Pematang Johar, Deli Serdang Regency, North Sumatra has been carried out. The results of chemical analysis from the analysis of pH H_2O, P and total K, Organic C, N Kjehldahl, and CEC (Cation Exchange Capacity) at the edges and middle respectively obtained that the pH was in the acid range, the total P content was quite high, the K content was low, the organic C content was high, the N content was low, and the CEC value was high. Related species of *Bacillus* contained in the soil were Gram-positive, rod-shaped, spore-forming, aerobic or facultative anaerobic, motile bacteria with peritrichous flagella. This study was expected to increase the knowledge of soil properties in organic farming systems including chemical analysis and soil microbiology.

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