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ANALYSIS OF SOIL ORGANIC CARBON CONTENT, TOTAL SOIL NITROGEN, AVAILABLE SOIL PHOSPHORUS, AND SOIL DENSITY IN INCEPTISOL SOILS UNDER VARIOUS GROUND COVER CROPS VEGETATION

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Abstract. Loamy soil is one of the characteristics of fertile soil, but basically loamy soil is not necessarily considered healthy soil. Soil fertility is determined by the dynamics of organic matter and the availability of essential macro nutrients contained in the soil. Loamy soil currently influences the decomposition process of organic matter in the soil. Inceptisol soil is a young soil type that continues to develop and has low to moderate organic matter content depending on the vegetation that occurs on the soil. In managing the fertility and health of Inceptisol soil, improvements are made by adding organic matter and understanding the dynamics of nutrients contained in Inceptisol soil. Soil fertility is a very important aspect in agriculture to support plant growth.
Keywords: Inceptisol, loamy soil, organic matter, vegetation

Abstrak. *Tanah gembur menjadikan salah satu ciri-ciri tanah yang subur, namun pada dasarnya tanah gembur belum tentu disebut sebagai tanah yang sehat. Kesuburan tanah ditentukan dari adanya dinamika bahan organik dan ketersediaan unsur hara makro esensial yang terkandung di dalam tanah. Tanah gembur saat ini mempengaruhi adanya*

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proses dekomposisi bahan organic di dalam tanah. Tanah Inceptisol merupakan jenis tanah muda dimana terus berkembang dan memiliki kandungan bahan organik yang rendah hingga sedang tergantung dari vegetasi yang terjadi di atas tanah. Pada pengelolaan kesuburan dan kesehatan tanah Inceptisol ini ialah dengan melakukan perbaikan melalui pemberian bahan organik serta mengetahui dinamika nutrisi yang terkandung di dalam tanah Inceptisol. Kesuburan tanah menjadikan sebuah aspek sangat penting di dalam pertanian untuk mendukung pertumbuhan tanaman.

***Kata Kunci**: Inceptisol, tanah gembur, bahan organik, vegetasi*

INTRODUCTION

Mineral soil is one type of soil that has great potential for plant growth. Mineral soil contains nutrients, particularly in terms of its chemical properties, which are excellent for analysing its sustainability.

Inceptisol soil is soil that lacks nutrients, such as soil chemical properties, namely soil acidity (pH), which is classified as low, macro nutrients such as N, P, K, Mg, Ca that are unstable or not high, low CEC (cation exchange capacity), and low nutrient status such as base saturation (BS), Organic Carbon (C-Organic) which is also low or even deficient in nutrients (Madjid, 2010 *in* Setyawan, 2021).

Inceptisol soil is a type of young soil that is still developing and retains characteristics similar to its parent material. Inceptisol soil is a soil order commonly found in Indonesia and is often used as a medium for growing plants or as agricultural land.

A common problem associated with Inceptisol soil is its low nutrient content, resulting in underdeveloped soil. Low nutrient content, such as N, P, and K, is a major problem in Inceptisol soil, so continuous improvements are made to Inceptisol soil to maintain its fertility and health. Natural improvement and management of Inceptisol soils can be seen in the role of vegetation on the surface of Inceptisol soils. Another problem is that these soils are prone to erosion, meaning that they are unstable and easily carried away by water and wind. A further problem is the instability of soil acidity (pH), with Inceptisol soils varying in acidity levels. Soil pH greatly affects plant growth. This requires manual management with the application of organic fertilizers, but this requires a large population, so the natural vegetation of ground cover plants greatly supports the

level of natural management of soil pH. Soil acidity management may need to be adjusted according to plant requirements (Sakiah *et al*., 2025 *in* Lubis *et al*., 2023; Lubis *et al*., 2026).

Increased decomposition of organic matter in Inceptisol soils leads to increased release of organic carbon into the atmosphere in the form of CO_2 (*carbon dioxide*) and reduces the amount of carbon stored in the soil. The level of carbon content in the soil and plants reflects the fertility and health of the soil, which in turn affects carbon storage in the soil and carbon emissions into the atmosphere.

Soil organic matter and soil organic carbon both play an equally important role in determining carbon in the soil. Carbon stocks can also change due to erosion and carbon redistribution on the soil surface (Roose *et al*., 2006 *in* Suyana *et al*., 2022; Ma *et al*., 2022).

Plant vegetation plays a significant role in protecting the soil from rain, which causes erosion and damage to the soil structure, and makes the soil compact and less prone to erosion. The denser the plant vegetation, the easier it is to improve the soil in the process of carbon sequestration and soil fertility will increase.

Based on the results of research by Amolikondri *et al*. (2022), in Hyrcanian forests (temperate climate), SOC, total N, and soil P stocks at a depth of 0-20 cm correlate with clay soil texture, while total N, organic C, and sand content have a positive impact.

Vegetation itself serves to protect plants from soil structure damage and erosion. Therefore, with more ground cover vegetation, there will be an increase in soil carbon sequestration, and the soil will become better and more suitable for plants to grow and develop. Dead plant debris will become organic matter for the soil. The loss of vegetation will cause the soil to be unprotected from heavy rainfall. Therefore, changing land use from land covered with ground cover plants to agricultural land will cause changes and reduce the level of biomass and vegetation carbon, soil fertility, and increase soil erosion.

This study was conducted with the aim of analysing the levels of soil organic carbon, total soil nitrogen, available soil phosphorus, and soil density in Inceptisol soils under various types of ground cover vegetation.

RESEARCH METHOD

a. Location and Time

The research was conducted over a period of five months, from October 2024 to March 2025. The research location was the palm oil plantation of PT. SIR (Surya Intisari Raya) Sei Lukut, Siak Regency, Riau Province.

b. Materials and Tools

In this study, the tools and materials used included field surveys using GPS, other tools such as soil sample rings, hoes, soil drills, plastic bags, knives, and measuring tapes. Laboratory equipment included Soil Carbon Analysis, Measuring Cups, Measuring Flasks, Analytical Scales, Droppers, Ovens, and 0.5 mm Sieves. The materials used included intact soil samples or soil taken using a soil ring at a depth of 20 cm, as well as soil taken randomly from cover crop vegetation at a depth of 20 cm.

The chemicals used to analyse soil samples are distilled water (H_2O), sulphuric acid (H_2SO_4), potassium dichromate ($K_2Cr_2O_7$), phosphoric acid (H_5PO_4), and iron sulphate ($FeSO_4$).

c. Research Methodology

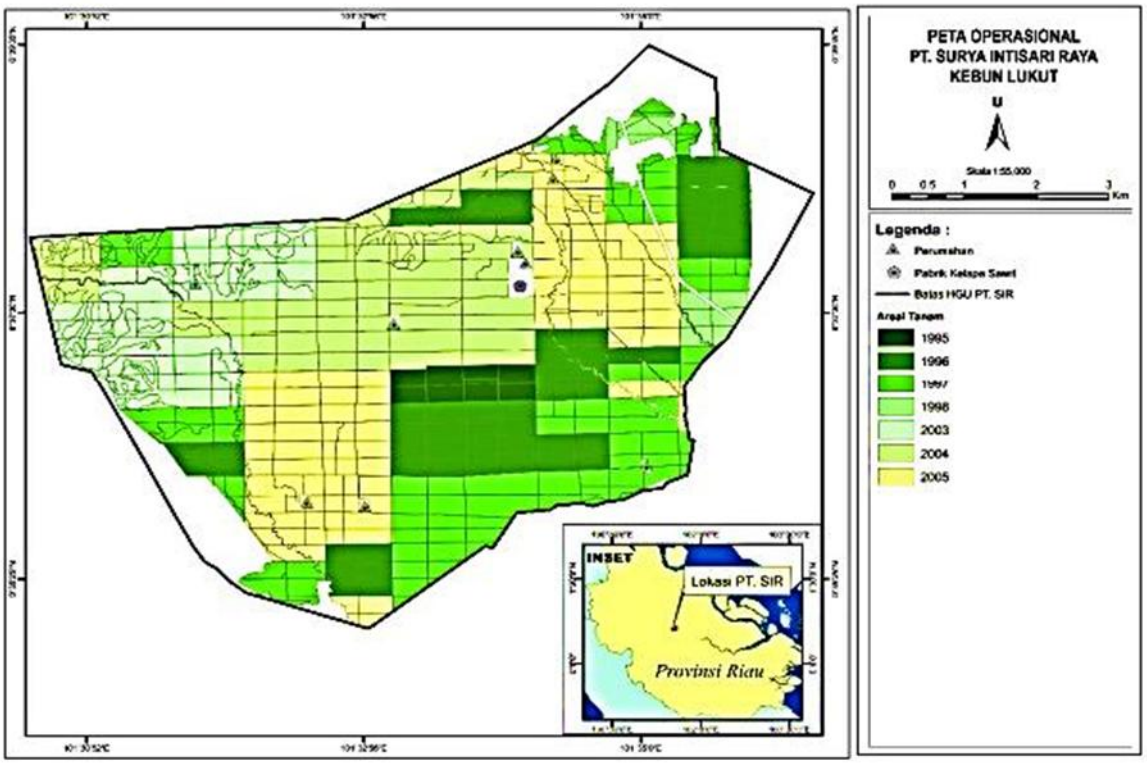
This study utilised a survey research method (direct observation in the field) by observing the condition and situation of the soil covered with various types of ground cover vegetation. This study also conducted analyses in a soil chemistry laboratory.

RESULT AND DISCUSSION

Determination of Research Location

Soil sampling and research were conducted at the PT. SIR (Surya Intisari Raya) Sei Lukut Palm Oil Plantation in Siak Regency, Riau Province. The research location map is as follows:

Figure 1. Map of the Research Location of PT. SIR Palm Oil Plantation



Source: Digital Map of PT. SIR Sei Lukut (2025)

Analysis of the Chemical Properties of the Soil Cover Plants *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit. in Inceptisol Soil

Analysis of the chemical properties of Inceptisol soil consists of analysis of soil organic carbon (C-Organic), total soil nitrogen (N-Total), available phosphorus content (P_2O_5-Available), and the physical properties of soil density in Inceptisol on ground cover vegetation consisting of *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit.

a. Soil Organic Carbon (C-Organic) Content in Ground Cover Plants *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit.

The content of soil organic carbon (C-Organic) is one of the keys to soil fertility and health, where the level of organic carbon originates from the amount of organic matter

in Inceptisol soil, thereby increasing the soil's ability to bind and absorb nutrients in the soil and absorb water for the survival and growth of plants. Soil organic carbon (C-Organic) content can reduce nutrient leaching, improve soil structure in Inceptisol soils, and balance nutrient levels in the soil. In terms of nutrient efficiency, organic carbon (C-Organic) content of more than 2% - 3% is considered optimal.

The following table shows the levels of Organic Carbon (C-Organic) in the Soil at the Research Location, as shown in Table 1 below:

Table 1. Organic Carbon Content Values in Inceptisol Soil

Observation	C-Organic Content (%)	Description
Mucuna bracteata	10,12	vh
Calopogonium caeruleum	9,88	vh
Laucaena leucocephala (Lam.) de Wit.	7,49	vh

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

Table 1 shows that the organic carbon content in ground cover plants consisting of *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit. vegetation in Inceptisol soil. Table 1 shows that ground cover plants in the form of *Mucuna bracteata* vegetation supply 10.12% more organic carbon to Inceptisol soil. Meanwhile, other vegetation such as *Calopogonium caeruleum* plants contributed 9.88% and *Laucaena leucocephala* (Lam.) de Wit. plants contributed 7.49%. The low organic carbon (C-Organic) content produced by several ground cover plant vegetation is due to the low organic matter content contained in the form of humus. This causes vegetation from *Mucuna bracteata* ground cover plants to produce the highest soil organic carbon (C-Organic) content, making *Mucuna bracteata* ground cover plants a source of nitrogen nutrients for plants and providing a *rhizosphere* to absorb nitrogen nutrients in the soil and supply them to plant roots.

This is in line with the opinion of Ariyanti *et al*. (2014) *in* Setyawan (2021) that the legume *Mucuna bracteata* is often used as a ground cover plant in oil palm plantations because it decomposes and produces large amounts of nitrogen, phosphorus and potassium, which are excellent nutrients for core crops such as oil palm.

Plants that supply nutrients, such as dead *Mucuna bracteata* vegetation that has turned into humus, are the largest component of organic carbon, along with leaves, twigs and roots from other plants.

The ground cover vegetation consists of dead *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit. The remains of this vegetation will decay and decompose by soil microbes, resulting in high levels of organic carbon in the Inceptisol soil.

b. Total Nitrogen (N-Total) Content of Soil in Ground Cover Plants *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit.

The total nitrogen (N-Total) content in Inceptisol soil comes from the decomposition of organic matter from plant and animal remains, fertilization, and rainwater. The main plants absorb nitrogen (N) nutrients through their roots and through the stomata of their leaves during rainfall and through foliar fertilizer spraying. The Total Nitrogen (N-Total) nutrient content of the soil is absorbed in the form of Ammonium (NH_4^+) and Nitrate (NO_3^-). One of the functions of the Nitrogen nutrient content is to improve plant growth and the formation of proteins from crop yields (Hardjowigeno, 2015).

The following table shows the total nitrogen (N-Total) content of the soil at the research site, as shown in Table 2 below:

Table 2. N-Total Content in Inceptisol Soil

Observation	N-Total Content (%)	Description
Mucuna bracteata	1,30	vh
Calopogonium caeruleum	1,10	vh
Laucaena leucocephala (Lam.) de Wit.	1,05	vh

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

The results of the analysis of Total Soil Nitrogen (N-Total) levels in Inceptisol soil show that the ground cover vegetation of *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit. plants shows differences, but the results are not significantly different. Oil palm plantations have ground cover vegetation with very high total nitrogen (N-Total) content in the soil. This is due to the total nitrogen content in the soil as a source of soil nitrogen after fertilization of oil palm plants.

The N-Total (Total Soil Nitrogen) content in Inceptisol soil is high due to the ground cover vegetation consisting of *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit. These plants produce high levels of biomass in the form of leaf litter, resulting in high total soil nitrogen content in Inceptisol soil.

According to Nopsagiarti *et al*. (2020), total nitrogen content in soil is balanced. Soil organic carbon and total nitrogen content will be balanced through the carbon and nitrogen ratio, which is very important in providing nutrients in the soil.

Meanwhile, according to Lubis *et al*. (2023) *in* Lubis (2026), soil organic carbon content is needed by soil microbes as energy, and nitrogen nutrient content is needed for protein formation. If carbon and nitrogen availability is insufficient, microbes will experience a lack of energy to bind free nitrogen compounds in the air. This is in line with the opinion of Abdila *et al*. (2022) *in* Salsavira (2024) that the abundance of nitrogen nutrients in the soil and the number of soil microbes indicate that the soil fertility level is good and suitable for plant growth.

c. Available Phosphorus Content (P_2O_5-Available) in Soil for Ground Cover Plants *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit.

The phosphorus content in the soil is absorbed by plants in the form of $H_2PO_4^-$ and HPO_4^-. The available phosphorus content (P_2O_5-available) in the soil can improve the quality of Inceptisol soil because the phosphorus content in the soil stimulates plant root growth, especially young plant roots. In addition, phosphorus also has a function in protein formation, assisting in the assimilation process, accelerating flowering and seed and fruit ripening, accelerating maturation and strengthening stems so that they do not easily fall over (Hardjowigeno, 2015; Harsono *et al*., 2012).

The following table shows the available phosphorus (P_2O_5-available) content of the soil at the research site, as shown in Table 3 below:

Table 3. P_2O_5-Available Value in Inceptisol Soil

Observation	P_2O_5-Available Content (ppm P)	Description
Mucuna bracteata	41,70	vh
Calopogonium caeruleum	27,99	h
Laucaena leucocephala (Lam.) de Wit.	25,60	h

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

From the observations in Table 3, it can be seen that the available phosphorus nutrient content (P_2O_5-Available) in Inceptisol soil shows high and very high criteria. The very high criteria are found in the vegetation of *Mucuna bracteata* ground cover plants with a P content of 41.70 ppm. This shows that soil acidity greatly affects the level of available phosphorus nutrients. The content at the soil acidity level (pH) of the soil in the *Mucuna bracteata* plant vegetation is higher. This is in line with the opinion of Henny *et al*. (2021) *in* Harahap *et al*. (2022) that this is because the acidity level of Inceptisol soil is slightly acidic, so that phosphorus nutrients are easily fixed by aluminium (Al) ions, felium (Fe) ions and calcium (Ca) ions, which will form insoluble compounds.

d. Soil Density (*Particle Density*) in Ground Cover Crops Plants *Mucuna bracteata*, *Calopogonium caeruleum*, and *Laucaena leucocephala* (Lam.) de Wit.

Soil density, better known as particle density, indicates the condition of the soil in terms of its pores and porosity, as well as the ability of plant roots to penetrate the soil in search of nutrients and water.

The following table shows the soil density (*particle density*) at the research site, as shown in Table 4 below:

Tabel 4. Nilai Kepadatan Tanah Inceptisol

Observation	Particle Density Content ($g.cm^{-3}$)	Soil Porosity Level (%)	Description
Mucuna bracteata	1,42	48,73	h
Calopogonium caeruleum	1,36	44,15	h
Laucaena leucocephala (Lam.) de Wit.	1,35	42,65	h

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

From the results of laboratory analysis of the physical properties of soil, namely observations of soil density, soil porosity and soil particles were observed. This testing is necessary because the ability of ground cover vegetation to provide organic matter and organic carbon in Inceptisol soil can reduce soil density, particularly in soil particles. In accordance with the opinions of Henny *et al*. (2021) and Alfarizi *et al*. (2023), decomposed organic matter that has become humus will quickly help reduce soil density, and soil with better drainage and erosion conditions will quickly help increase porosity and reduce soil particle content.

CONCLUSION

Based on the research results, it was concluded that Inceptisol soil showed soil improvement in determining the levels of Organic Carbon (C-Organic), Total Soil Nitrogen (N-Total), and Available Soil Phosphorus (P_2O_5-Available), and showed the highest ground cover vegetation in *Mucuna bracteata* plants. Furthermore, soil density and porosity were better in the ground cover vegetation of *Mucuna bracteata* plants.

REFRENCE

Abdila, A., Japarang, N., Agustin, N., Hafni, W., Annisi, A. D., Karim, H., Azis, A., Junda, M., & Jumadi, O. (2022). Populasi Mikroorganisme Tanah pada Lahan Jagung setelah Aplikasi Pupuk Poliakrilat. *Jurnal Ilmu Pertanian*, 27(1): 18-21.

Alfarizi, T. M., Khalil, M., & Yusnizar. (2023). Kajian Stok Karbon Organik dan Nitrogen Total Tanah pada Berbagai Jenis Tanaman Penutup Tanah di Kebun Kelapa Sawit. *Jurnal Rona Teknik Pertanian*, 16(2): 194-203.

Amolikondri,A., Abrari Vajari, K., & Feizian, M. (2022). Assessing Soil Organic Carbon, N, and P Stocks and its Relation to Soil Properties in Artificial Canopy Gaps in a Managed Oriental beech (*Fagus orientalis* L.) Forest. *Journal of Plant Nutrition and Soil Science*, 185(2): 243-250.

Ariyanti, M., Yahya, S., Murtilaksono, K., Suwarto, Siregar, H. H. (2014). Potential use of *Nephrolepsis biserrata* as Cover Crop under mature Oil Palm Plantation. *International Comference on Multidisciplinary Research*, pp. 120-123.

Harahap, A. A., Idwar, Oktorini, Y., Qomar, N., Darlis, V. V., & Pebriandi. (2022). Identifikasi Sifat Fisik Tanah Inceptisol pada Penggunaan Lahan (Land Used) di Sekitar Kawasan Kampus Bina Widya Universitas Riau. *Sylva: Jurnal Penelitian Ilmu-Ilmu Kehutanan*, 11(2): 58-65.

Hardjowigeno, S. (2015). Ilmu Tanah. Edisi Keempat. *Akademia Pressindo*, Jakarta. pp. 59-92.

Hasono, W. A., Harahap, I. Y., Yusran, P., & Taufiq, C. H. (2012). Penggunaan berbagai Jenis Legume Cover Crop (LCC) pada Pertumbuhan Kelapa Sawit (*Elaeis guineensis* Jacq) di Lahan Gambut. *Warta Pusat Penelitian Kelapa Sawit*, 17(2): 45-50.

Henny, H., Septiani, W., & Tamzi, F. (2021). Dinamika Simpanan Karbon dan Kepadatan Tanah setelah Pengolahan Tanah. *Jurnal Agroecotenia*, 4(1): 38-48.

Lubis, E. J. (2026). Effect of *Eichhornia crassipes* Zucc. Liquid Green Manure and Potassium on Growth and Production of *Solanum melongena* L. in Inceptisol Soil. *Jurnal Media Akademik*, 4(2): 1-15.

Lubis, E. J., Rauf, A., & Sarifuddin. (2023). Effectiveness of Fertilization Techniquess on Growth Two Varieties of Palm Oil Seeds (*Elaeis guineensis* Jacq.) in Main Nursery. *Journal of Social Research*, 2(8): 2759-2772.

Ma, H., Tecimen, H. B., Ma, F., Imran, S., Gao, R., Yin, Y., & Sun, J. (2022). Different Responses of Soil Nitrogen to Combined Addition of Labile Carbon Sources with Fresh Versus Decomposed Litter. *Journal of Plant Nutrition and Soil Science*, 185(2): 232-242.

Majid. (2010). Sifat dan Ciri Tanah. Fakultas Pertanian, Institut Pertanian Bogor. Bogor.

Nopsagiarti, T., Okalia, D., & Marlina, G. (2020). Analisis C-Organik, Nitrogen dan C/N Tanah pada Lahan Agrowisata Beken Jaya. *Jurnal Agrosains dan Teknologi*, 5(1): 11-18.

Roose, E. J., Lal, R., Feller, C., Barthes, B., & Stewart, B. A. (2006). Soil Erosion and Carbon Dynamics (Advances in Soil Sciences). *CRC Press. Taylor & Francis Group, LLC*.

Sakiah, Purba, I. T., & Basri, A. H. H. (2025). Dinamics of Soil Respiration, Organic Carbon, and Soil Moisture under Different Ground Cover Vegetation and Liquid Organic Fertilizer in Smallholder Plantations. *Jurnal Agro Industri Perkebunan*, 13(3): 195-204.

Salsavira, K. (2024). Analisa Kandungan C-Organik Tanah dan Total Populasi Mikroorganisme Tanah sebelum dan setelah Aplikasi Pupuk Organik Blotong pada Lahan Tebu PTPN XI di Kebn Mrawan dan Kebun RVO Tapen. *Jagad Tani: Jurnal Ilmu Pertaian*, 1(1): 1-11.

Setyawan, B. (2021). Kajian Berbagai Tanaman Penutup Tanah terhadap Sifat Kimia Tanah pada Inceptisol dan Spodosol di Perkebunan Kelapa Sawit PT. Bumitama Gunajaya Agro. *Skripsi*, Prodi Agroekoteknologi Universitas Brawijaya. Malang.

Suyana, J., Krismonanto, W., Muliawati, E. S., Widijanto, H., & Hartati, S. (2022). The Characteristics of Vegetations, Soil Nutrients of Nitrogen and Soil Organic Carbon at Forest Stands of Mount-Merbabu National Park and Dry Field. *Jurnal Penelitian Pengelolaan Daerah Aliran Sungai*, 6(2): 141-160.