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Enhancing Soil Fertility in Coffee Plantations: Effects of Biopore Infiltration Holes with Compost (BIHC) on Total Soil Nitrogen and Plant Growth

Dinda Mahartian Yunita[1*], Atiqah Aulia Hanuf[1,2*], M. Wasilul Lutfi[1], Soemarno[1]

1 Soil Science Department, Faculty of Agriculture, Brawijaya University. Jl. Veteran No.1, Malang, East Java, Indonesia. Tel./Fax. +62-341-553623,

2 Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology, No.1, Shuefu Road, Neipu, Pingtung 912301, Taiwan. Tel. +886-8-7703202

*corresponding author: atiqahaulia@ub.ac.id

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Abstract

Nitrogen loss in coffee plantations reduces soil fertility and impacts coffee production. This study evaluated Biopore Infiltration Holes with Compost (BIHC) to enhance total soil nitrogen (N) and its effects on coffee plant growth. Using a randomized block design with seven treatments, we found that BIHC significantly increased total soil N, with the highest values (0.29% at 60 DAA and 0.36% at 90 DAA) in the 30 cm biopore with goat compost treatment at 0-20 cm depth. Total N positively correlated with leaf number ($r = 0.48$) and chlorophyll content ($r = 0.71$ at 0-20 cm depth). These findings support sustainable soil fertility management in coffee plantations, contributing to SDG 2 by enhancing agricultural productivity and SDG 12 by recycling organic waste.

Keywords: biopore infiltration holes; coffee pulp compost; goat manure; coffee productivity; sustainable agriculture

Introduction

Indonesia's coffee production has generally increased over the past five years. Based on the Indonesia Statistics 2023 report, coffee production in 2022 reached 794.8 thousand tons, reflecting a 1.1% rise compared to the previous year. Production continued to grow in 2019 and 2020, reaching 752.5 thousand tons and 762.4 thousand tons, respectively. By 2021, coffee production had further increased to 786.2 thousand tons (BPS-Statistics Indonesia, 2024). The production results cannot be separated from the role of various types of nutrients in the soil, one of which is nitrogen. Nitrogen loss due to runoff in coffee plantations reduces soil fertility and limits productivity, particularly in regions with compacted soils and high rainfall. Effective nitrogen management is crucial for sustainable coffee production. Maintaining optimal soil nitrogen levels is essential for achieving high coffee bean yields. Total soil nitrogen levels should be monitored to ensure they meet the critical thresholds recommended for optimal coffee production (Sudharta et al., 2022).

Soil fertility management is a critical component of sustainable agricultural practices, directly influencing food security, ecosystem health, and economic stability. The United Nations Sustainable Development Goals (SDGs) provide a framework for addressing these challenges by promoting sustainable practices that enhance soil health and fertility. Soil fertility management is an eco-friendly and cost-effective approach that combines organic and inorganic fertilizers to enhance soil fertility and crop productivity. This approach aligns with SDGs 2 (Zero Hunger) by increasing agricultural productivity and ensuring food security.

Organic amendments, such as compost, play a significant role in improving soil fertility and health. Recycling organic waste enhances soil quality and contributes to achieving the SDGs by promoting sustainable land management practices (Ajibade et al., 2022). Organic amendments help mitigate the negative impacts of chemical fertilizers, which can degrade soil health over time. This aligns with SDGs 12

(Responsible Consumption and Production) by encouraging sustainable practices that reduce waste and enhance soil quality. Another benefit of applying compost is reducing surface runoff and leaching of nitrates from the root zone of plants. Giving goat manure can increase soil fertility and improve soil structure by stabilizing soil aggregates, aeration and water holding capacity, and cation exchange capacity (Goldan et al., 2023; González-Torres et al., 2024). Meanwhile, coffee pulp compost in cultivated plants improves the soil's physical, chemical, and biological characteristics, maintaining and increasing soil fertility (Sánchez-Reinoso et al., 2023).

A technology called Biopore Infiltration Holes with Compost (BIHC) has been discovered in soil and water conservation. BIHC is a soil conservation technology that contains biopore infiltration holes and compost. BIHC functions include maximizing the amount of rainwater that seeps into the soil so as to increase groundwater, making natural compost from organic waste, reducing standing water on the soil surface, reducing rainwater which becomes surface runoff, maximizing the role and activity of soil flora and fauna, and reduce the occurrence of soil erosion (Hanuf et al., 2021). BIHC technology has advantages, such as reducing surface runoff and being a composting site for organic matter, the results of which plants can use for their growth (Hanuf et al., 2021). Few studies have examined the combined use of biopore infiltration holes and compost to address nitrogen loss in coffee plantations.

The research location shows that the soil texture is clayey, the soil surface layer is compaction, the organic matter and soil total-N are low, and the runoff volume is very large in the rainy season. These facts suggest that the efficiency of fertilizers and manure in coffee plantations is still low, and they have not been able to increase coffee plants' productivity optimally. This is thought to be related to the loss of fertilizer and manure carried by the runoff during the rainy season. Therefore, the use of composted BIHC technology in coffee plantations needs to be studied more deeply, including its effect on the total-N content in the soil in the root zone of coffee plants.

Materials and Methods

Study area

The research was located at PTPN XII Kebun Bangelan, Wonosari District, Malang Regency. The coordinates of PTPN XII Kebun Bangelan are 8 ° 04'38 "LS and 112 ° 28'58" East Longitude, with an altitude of 450 - 680 meters above sea level. The topography of PTPN XII Kebun Bangelan's coffee production area is hilly with a slope of 0-40%. Soil condition in the research location has clayey texture, fast drainage, compacted soil, and low levels of soil organic carbon (Hanuf et al., 2021). Annual rainfall around 2000 – 3000 mm. Meanwhile, chemical analysis was conducted at the Laboratory of Soil Chemistry, Faculty of Agriculture, Brawijaya University.

Procedures

Experimental Design

The research used the experimental method, a randomized block design with 4 replications and 7 treatments. The treatments used were the biopore depth and the compost type. A diameter of biopore is 10 cm. Goat manure compost dosage is 12.02 ton $ha^{-1,}$ and coffee pulp compost is 24.26 ton ha^{-1} and applied at the start of the rainy season. Organic material is introduced into the biopore holes with 30 and 60 cm depth. The treatment was in the form of giving biopores with a depth of 30 cm, 60 cm and a combination of 30 cm and 60 cm, respectively, as well as the type of compost treatment, namely coffee pulp compost, goat manure and control. Based on this treatment, the combination carried out is the treatment without biopores and without compost (P1), 30 cm biopore and goat compost (P2), 30 cm biopore and coffee pulp compost (P3), 60 cm biopore and goat compost (P4), 60 cm and coffee pulp compost (P5), 30 cm and 60 cm biopores and goat compost (P6), and 30 cm and 60 cm biopores and coffee pulp compost (P7). Each treatment was repeated 4 times. Observations were made 0 days after application (DAA), 60 DAA, and 90 DAA. Observations were made with each depth of 0-20 cm, 20-40 cm, and 40-60 cm soil depth.

Laboratory analysis

Parameters observed included soil total N (Kjeldahl), total leaf numbers, and total chlorophyll using SPAD. The Kjeldahl method is a widely used procedure for determining total nitrogen in soil, consisting of three main steps: digestion, distillation, and titration. Digestion (conversion of organic nitrogen to ammonium) using H_2SO_4 and catalyst mixtures such as K_2SO_4 and selenium. Distillation (conversion of ammonium to ammonia) using NaOH and boric acid. Titration (quantification of nitrogen) using HCl. Total chlorophyll was measured by randomly collecting five mature (fully developed) leaves from each coffee tree to measure total chlorophyll using SPAD. SPAD readings were converted to chlorophyll content using the equation by (Netto et al., 2005). Observations were made thrice, 0, 60, and 90 days after application (DAA). The equation model for transforming the SPAD index (SPAD: Soil-Plant Analyses Development, Konica Minolta Sensing, Model number 72923021) into the chlorophyll content is defined by (Netto et al., 2005): Y= 44.5885+0.7188X+ 0.0933X2 ………. (1), where, X is the data from SPAD measurement, Y is the content of total chlorophyll (µmol m^{-2}).

Data analysis

The data obtained were analyzed with the SPSS application using analysis of variance (ANOVA) at a 5% level. If the treatment shows a significant effect on the results of the observation, then a further test is carried out using the LSD test with a level of 5%.

Result and Discussion

Effect of BIHC on the Soil Total N Content

The analysis showed that BIHC treatment significantly affected the soil total N. Based on the analysis results, it is known that the highest value is 60 DAA with 30 cm biopore + goat compost (P2) at a depth of 0-20 cm. Still, it is not significantly different from the 30 cm biopore + coffee pulp compost (P3), 60 cm biopore + goat compost (P4), and a biopore combination of 30 and 60 cm + goat compost (P6). While the highest analysis results were at 90 DAA also at a soil depth of 0-20 cm with 30 cm biopore + goat compost (P2), but not significantly different from 30 cm biopore + coffee pulp compost (P3), 60 cm biopore + goat compost (P4), and a combination of 30 + 60 cm biopore + goat manure compost (P6).

At 60 DAA (Table 1), the total-N content in the BIHC 60 cm + goat manure compost (P4) at a 20-40 cm depth had the highest value among other treatments. However, it was not significantly different from the treatment of BIHC 30 cm + goat compost (P2) and BIHC 30 + 60 cm + goat manure compost (P6). Whereas at a depth of 40-60 cm, the highest value was found in the BIHC 60 cm + goat manure compost (P4), but it was not significantly different from the BIHC 30 cm + goat manure compost (P2), BIHC 30 cm + coffee pulp compost (P3), and BIHC 30 + 60 cm + goat manure compost (P6). At 90 DAA, the total-N value with BIHC 30 cm + goat manure compost (P2) at a depth of 20-40 cm had the highest value for each treatment at the same depth. However, this value was not significantly different from the treatment of BIHC 60 cm + goat manure compost (P4), BIHC 60 cm + coffee pulp compost (P5), BIHC 30 + 60 cm + goat manure compost (P6), and BIHC 30 + 60 cm coffee pulp compost (P7).

Table 1. Soil Total-N content in various BIHC treatments

Treatment	Soil Depth at 60 DAA (cm)			Soil Depth at 90 DAA (cm)		
	0-20	20-40	40-60	0-20	20-40	40-60
P1: Control	0.11a	0.12a	0.11a	0.17a	0.15a	0.12
P2: BIHC 30cm+Goat manure compost	0,29c	0,19 bc	0,16 bc	0,36c	0,23 b	0,21 c
P3: BIHC 30cm + coffee pulp compost	0,22 bc	0,15 ab	0,13 abc	0,25 abc	0,16a	0,17 bc
P4: BIHC 60cm + Goat manure compost	0,23bc	0,22c	0,17c	0,33 bc	0,23 b	0,21c
P5: BIHC 60cm + coffee pulp compost	0,14ab	0,14 ab	0,12 ab	0,24 ab	0,19 ab	0,17 bc
P6: BIHC 30+60cm + Goat manure compost	0,20 abc	0,20c	0,17c	0,29 bc	0,23 b	0,20c
P7: BIHC 30+60cm + Coffee pulp compost	0,19 ab	0,15 ab	0,14 abc	0,25 ab	0,19 ab	0,13 ab

Note: DAA: days after application. The numbers accompanied by the same letter in the same column show no significant difference in the LSD test at the 5% level.

The results showed that the total-N value by giving goat manure compost was higher at 60 DAA and 90 DAA with a 0-20 cm depth. The increase in total-N from 60 DAA to 90 DAA in the BIHC 30 cm + goat manure compost (P2) was 0.07%, while the lowest value was at a depth of 40-60 cm with a BIHC 60 cm + coffee pulp compost (P5) at 60 DAA and combination of BIHC 30 + 60 cm + coffee pulp compost for 90 DAA. Lack of nitrogen can limit cell division and formation, and the formation of chlorophyll inhibits plant growth and makes the leaves look yellowish (Firmansyah & Sumarni, 2013; Sumiati & Gunawan, 2006). Based on the research analysis, the nutrient content of goat manure compost includes total nitrogen (N-total) of 1.98%, total phosphorus (P-total) of 1.48 ppm, organic carbon (C-organic) of 32.28%, and a pH of 7.24. Meanwhile, the nutrient content of coffee husk compost includes total nitrogen (N-total) of 1.04%, total phosphorus (P-total) of 0.25 ppm, organic carbon (C-organic) of 19.02%, and a pH of 7.18. Goat manure has a higher nitrogen content compared to coffee pulp, making it a more immediate source of nitrogen for plants (Marbun et al., 2024; Navianti et al., 2023). In contrast, coffee pulp has a higher carbon-to-nitrogen (C:N) ratio, which slows decomposition and delays nitrogen release into the soil (Cole

& Zahawi, 2021). The microbial activity in goat manure is also more diverse and efficient, leading to faster nitrogen mineralization, while the higher lignin content in coffee pulp further slows decomposition (Getachew, 2017; Shemekite et al., 2014). Additionally, goat manure enhances soil microbial biomass, improving nutrient cycling and organic matter breakdown more effectively than coffee pulp compost (Marbun et al., 2024; Navianti et al., 2023). Therefore, from this result, the recommended biopore treatment is BIHC 30 cm + goat manure compost because it can supply the total-N in the soil. This technology is expected to enhance soil biota activity, leading to the formation of additional soil pores. These pores can function as water channels within the soil and act as water reservoirs for both the soil and plants. Additionally, BIHC technology optimizes compost application by incorporating it into the system, reducing surface runoff and preventing erosion (Hanuf et al., 2021).

Effect of BIHC on C/N Ratio

Based on the results of the C / N ratio analysis, at 60 DAA with a depth of 0-20 cm, the highest value of C/N ratio was found in the BIHC 60 cm + coffee pulp compost (P5) as well as at a depth of 20-40 cm and 40-60 cm, the highest value was found in the same treatment, namely BIHC 60 cm + coffee pulp compost (P5). The results of the analysis on 90 DAA with a depth of 0-20 cm, the highest value was in the BIHC 30 + 60 cm + coffee pulp compost (P7), at a depth of 20-40 cm the highest value was found in the BIHC 30 cm + coffee pulp compost (P3) depth of 40-60 cm, the highest value was found in the BIHC 30 + 60 cm + coffee pulp compost (P7). The analysis result of the C/N ratio showed that it was not significantly different as a whole treatment.

Table 2. Effect of LRB plus compost on C / N Ratio

Treatment	Soil Depth at 60 DAA (cm)			Soil Depth at 90 DAA (cm)		
	0-20 cm	20-40	40-60	0-20 cm	20-40	40-60
P1: Control	6.48	6.40	5.40	5.10	4.16	4.01
P2: BIHC 30cm+Goat manure compost	5.10	4.23	5.90	3.90	4.30	3.48
P3: BIHC 30cm + coffee pulp compost	6.21	4.78	5.38	6.40	6.62	5.06
P4: BIHC 60cm + Goat manure compost	5.74	3.58	4.00	3.69	3.64	3.26
P5: BIHC 60cm + coffee pulp compost	11.51	7.32	7.00	5.48	5.89	5.19
P6: BIHC 30+60cm + Goat manure compost	7.33	4.00	5.00	5.23	4.36	5.38
P7: BIHC 30+60cm + Coffee pulp compost	7.91	6.54	5.00	6.98	5.89	9.92

Note: DAA: days after application. The numbers accompanied by the same letter in the same column show no significant difference in the LSD test at the 5% level.

From the results described (Table 2), 60 DAA at a 0-20 cm depth had the highest C/N ratio value. This shows that the mineralization of organic matter is more effective in the topsoil. Topsoil, characterized by its higher organic matter content and biological activity, provides a more favorable environment for microbial processes that promote mineralization. Microbial communities in topsoil are generally more diverse and active than those in deeper soil layers. Studies have shown that mineral-associated organic matter (MAOM) in topsoil is significantly affected by microbial activity, which enhances organic matter stabilization through mineral interactions (Castellano et al., 2015; Mikutta et al., 2019). The microbial efficiency matrix stabilization (MEMS) framework states that mineral association is a key mechanism for organic matter stabilization, indicating that topsoil microbial dynamics are critical for adequate mineralization (Castellano et al., 2015). Therefore, topsoil has a higher organic matter content than that in the subsoil.

The mineralization process is a process that is responsible for the availability of N in the soil (Wijanarko & H Purwanto, 2016). Mineralization of soil organic matter involves the work of enzymes to hydrolyze complex protein compounds. In decomposition, microorganisms use carbon compounds in organic material to obtain energy, producing CO_2. During the decomposition process of organic matter, carbon emissions in the form of CO_2 occur so that the C/N ratio will be lower (Hossain et al., 2017). The higher the activity of microorganisms, the faster the decomposition process of organic matter can reduce the C-organic content (due to the release of CO_2 in the decomposition of organic matter). In contrast, the total N content is relatively constant, so the C/N ratio will decrease. A low C/N ratio indicates the mineralization process is going well (Pratiwi et al., 2016).

Effect of BIHC on Chlorophyll Content

The analysis results showed that BIHC was significant for the chlorophyll of coffee leaves (Table 3). The control treatment showed significant differences compared to all treatments, except for BIHC 30cm + coffee pulp compost (P3). Furthermore, the values in treatment P3 were not significantly different from BIHC 30+60cm + Goat manure compost (P6).

Table 3. BIHC application on the chlorophyll content

Treatment	The chlorophyll content
P1: Control	59,41 a
P2: BIHC 30cm+Goat manure compost	63,05 c
P3: BIHC 30cm + coffee pulp compost	60,53 ab
P4: BIHC 60cm + Goat manure compost	62,93 c
P5: BIHC 60cm + coffee pulp compost	64,67 c
P6: BIHC 30+60cm + Goat manure compost	62,60 bc
P7: BIHC 30+60cm + Coffee pulp compost	64,50 c

Note: Numbers accompanied by the same letter in the same column show insignificant differences in the BNJ test at the 5% level.

The significant effect of BIHC application on the increase in chlorophyll content (Table 3) indicates that there is a positive effect on increasing the chlorophyll content. Figure 2 (Total N of soil) shows that an increase in chlorophyll content accompanies an increase in total N soil. Nitrogen content is closely related to chlorophyll synthesis, protein, and enzyme synthesis (Wen et al., 2019; Yang et al., 2021). Rubisco enzyme acts as a catalyst in the fixation of CO2, which plants need for photosynthesis (Bouvier et al., 2024; Zhao et al., 2024). Therefore, plants' N content affects photosynthesis results through photosynthetic enzymes and leaf chlorophyll content. In the plant body, nitrogen is first in the form of ammonia, and then ammonia changes to glutamic acid, which is catalyzed by the enzyme glutamine synthetase. Glutamic acid is a basic ingredient in the biosynthesis of amino acids and nucleic acids. Glutamic acid is a precursor to the porphyrin ring for chlorophyll formation (Perchlik & Tegeder, 2018; Sun et al., 2023).

Chlorophyll is the main pigment used by plants to capture sunlight energy. The chlorophyll molecule consists of a porphyrin head (four nitrogen-containing pyrrole rings arranged in a ring formation around a magnesium cation) and a long hydrocarbon tail. This hydrocarbon tail is fat-soluble. Increased soil N enhances chlorophyll synthesis via glutamic acid production, boosting photosynthesis and leaf growth (Anas et al., 2020). Exporting nitrogen (N) from old plant parts and into young plant parts is very important for efficiently using this nitrogen nutrient. There was a significant correlation between the photosynthetic pigment content, N-total, and photosynthetic variables and the SPAD-502 readings in coffee leaves (Netto et al., 2005). This correlation can be analyzed between chlorophyll levels, N, and chlorophyll a and b, with SPAD-502 readings of coffee leaves at different times. The results of this analysis indicate that all variables decrease with time. However, the correlation increases linearly with the dose of N fertilizer. Total chlorophyll content showed a linear correlation with portable chlorophyll-meter readings. SPAD reading has proven to be a good tool for diagnosing the integrity of the photosynthetic system in coffee leaves. Thus, the portable chlorophyll SPAD502 instrument can be used to evaluate N status and can also help evaluate the photosynthetic process in coffee plants.

Implementing BIHC (Biopore Infiltration Hole) has been demonstrated to increase chlorophyll content, suggesting that using BIHC can improve soil water retention capacity and enhance its physical, chemical, and biological properties. These enhancements ultimately improve plant health and higher chlorophyll levels (Arifin et al., 2020). Adding organic materials, such as compost, into BIHC significantly improves soil quality and nutrient availability, which is critical for photosynthesis and chlorophyll synthesis (Alfiqri et al., 2024). Applying BIHC combined with organic waste accumulation has increased water infiltration rates, positively affecting soil moisture and plant water availability (Badu et al., 2023). Optimal soil moisture is essential for photosynthesis, as chlorophyll is key in light absorption and energy conversion (Muliani et al., 2023). Furthermore, studies have indicated that BIHC implementation can reduce waterlogging and improve soil aeration, thereby supporting root development and overall plant health (Haryanto et al., 2022). Farmers can adopt BIHC with goat compost to improve yields in nitrogen-deficient soils.

Relationship between N-Total Content and Number of Coffee Plant Leaves

The correlation test results show a strong relationship between the soil's total N content and the number of leaves, with a significant positive correlation coefficient (r = 0.48*). Figure 1 shows the value of R2 = 0.2362, which means that the contribution of the soil total N to the number of leaves is 23.62%, while other factors influence 76.38%. The regression model shows that if the total N increases by 1% (in the range of 0.1-0.4% N), it will be followed by an increase in the number of leaves by 149.9%. This indicates that the higher the N content in the soil, the more plant growth will increase.

Nitrogen is an essential macronutrient plants need in large quantities. Nitrogen is also very much needed by plants for the formation or vegetative growth process of plants such as roots, stems, and leaves

(Shah et al., 2024; Wang et al., 2024). The need for N increases with plant age, especially in the early fruit and seed formation stages. If there are no other limiting factors, an adequate supply of N will promote rapid plant development, particularly through an increase in the number of leaf pairs and the number of branches per plant, the number of nodes per branch, the number of flowers, and fruits per node, all related to the yield of coffee beans higher (Martinez et al., 2024). In addition, N is a determining factor for protecting coffee plants against photo-inhibition of photosynthesis when the plants are exposed to high radiation intensity (Pompelli et al., 2010).

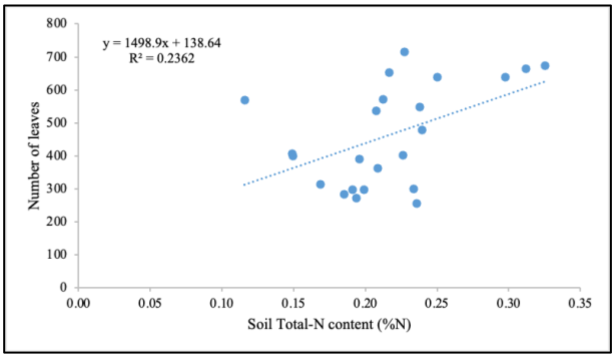

Figure 1. The relationship between the N-total soil content (%) and the number of leaves of the coffee plant.

The relationship between the total N and the chlorophyll content

The correlation and regression test results show a significant relationship between N-total and chlorophyll. The correlation test results in 0-20 cm of soil depth showed a positive correlation coefficient (r = 0.71*). In the 20-40 cm of soil depth, the correlation between chlorophyll content and soil total N is r=0.70*; in the 40-60 cm of soil depth, it is r=0.66*.

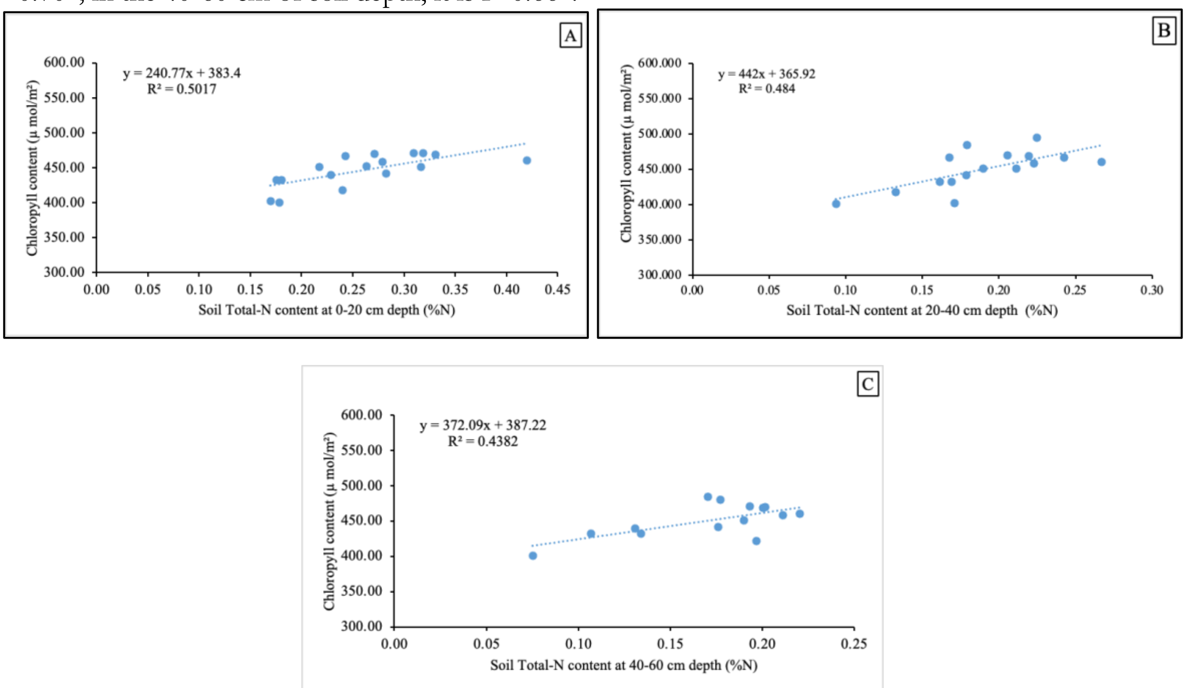

Figure 2. Relationship between total N of soil (a: 0-20 cm soil depth; b: 20-40 cm soil depth; c: 40-60 cm soil depth) and chlorophyll content of coffee leaves

The relationship between the total N of soil at a depth of 0-20 cm and the value of leaf chlorophyll content (Fig. 2a) shows the value of R2 = 0.5017. This means that the contribution of the effect of the total N content to the chlorophyll content is 50.17%, while other factors influence the remaining 49.83%. The regression model shows that if the total N-content of the soil increases, it will be followed by an increase in the SPAD value (reflecting the chlorophyll content of coffee leaves). This can occur because an increase usually follows the increase in the total N of the soil in the availability of N for plants, and ultimately, an increase in N uptake by coffee plants and an increase in leaf chlorophyll synthesis (Ramirez-Builes et al., 2024). The roots of mature coffee plants are concentrated in soil layers 0-60 cm so that coffee plants can absorb water and nutrients (including N) from this soil depth zone. Therefore, increasing the total N-content of the soil at this depth is expected also to increase the N uptake by coffee plants. This increase in the N uptake of coffee plants means that more N is available for chlorophyll synthesis in the plant body. Thus, increasing the total N-content in the soil with a depth of 20-40 cm is expected to increase the chlorophyll content of coffee leaves.

It has a significant relationship based on the results of correlation and regression tests between total N and chlorophyll content. The correlation test results showed a positive correlation coefficient (r = 0.70*). The figure shows that the value of R2 = 0.484 indicates that the contribution of the effect of the total N content to the chlorophyll content is 48.4%, while other factors influence the remaining 51.6%. The regression model shows that if the total N-content of the soil increases, it will be followed by an increase in the SPAD value (reflecting the chlorophyll content of coffee leaves). The results of research conducted by other researchers also showed that leaf chlorophyll content is closely related to the N content in plants (Netto et al., 2005; Pompelli et al., 2010).

Based on the correlation and regression test results, the N-total to the chlorophyll content has a significant relationship. The correlation test results showed a positive correlation coefficient (r = 0.66 *). The figure shows the value of R2 = 0.4382, which means that the contribution of the effect of the total N content to the chlorophyll content is 43.82%, while other factors influence the remaining 56.18%. The regression model shows that if the total N-content of the soil increases, it will be followed by an increase in the SPAD value (reflecting the chlorophyll content of coffee leaves). Several other researchers also carried out similar studies, showing that increasing the nutrient content in the soil could increase nutrient uptake by coffee plants (Liu et al., 2016; Silva et al., 2019).

Conclusion

The best application of BIHC to the soil total N content is in the BIHC 30 cm of goat manure compost (P2) at a depth of 0-20 cm, with a value of 0.36% at 0-20 cm depth. The relationship between the soil Total-N content and the number of coffee leaves has a moderate closeness and has a positive correlation value (r = 0.48). Soil N-total affects the growth in the number of leaves and chlorophyll in coffee plants (r = 0.71). This sustainable practice enhances soil fertility and coffee productivity, supporting SDG 2 by improving food security and SDG 12 by recycling organic waste.

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