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Liquid organic matter from banana peel improves morpho-physiological traits of coffee seedlings

Abstract. Due to its economic advantage, the Robusta coffee clones BP 308 and BP 939 are widely grown. Many factors affect coffee growth during the cultivation practice, especially in the availability of adequate nutrients at the nursery stages. Apart from inorganic fertilizer application, organic matter needs to be applied in the nursery stages to support plant growth, such as applying liquid organic matter (LOM) derived from banana peel waste. This study was conducted to find out how the LOM of banana peels affected the morphological and physiological responses of BP 308 and BP 939 clone Robusta coffee seedlings and what proper dosages of LOM were needed. The experiment was conducted at the Ciparanje Experimental Station, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor from January to April 2022. This experiment used a randomized block design method consisting of 10 treatments and 3 repetitions. The treatments tested included 1.5 g of NPK inorganic fertilizer; 10 mL.L^{-1}.plant^{-1} LOM ; 20 mL.L^{-1}.plant^{-1} LOM; 30 mL. L^{-1}.plant^{-1} LOM and 40 mL. L^{-1} .plant^{-1} LOM that was given to both clones, namely BP 308 and BP 939. The results of this experiment showed that there were differences in the effect of LOM between BP308 and BP939 on the morphological response such as an increase in plant height and leaf number, on the physiological response such as chlorophyll index and stomatal conductance at the 3 months after treatment (MAT). The BP939 was partly better in response to LOM of 10 mL.L^{-1}.plant^{-1} on plant height, the BP308 was partly better in stomatal conductance.

Keywords: Banana peel waste · Clone BP 308 · Clone BP 939 · Robusta

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Introduction

One of Indonesia's top plantation commodity crops is coffee plants (*Coffea* sp.). It can significantly increase national economic income by providing income for farmers, producing industrial raw materials, and creating jobs (Simaremare, 2022). According to information from the Directorate General of Plantations (Ditjenbun, 2019), Indonesia produces about 700,000 tons of coffee annually, or about 9% of the world's total production. Indonesia is now the world's fourth-largest coffee producer, behind Brazil, Vietnam, and Colombia (Martauli, 2018). Raising domestic coffee's production and quality will make it more competitive in the global market (Akbar, 2019).

Arabica, Robusta, and Liberica are the three coffee varieties popular in Indonesia, according to Danarti (2007), Robusta and Arabica coffee are well-known for having a high economic worth (Wihartanto, 2017) with a production value of 70.14%. Robusta coffee predominates on Indonesian coffee plantations due to its advantages with environmental conditions such as resistance to disease, leaf rust, and high production (Martauli, 2018; Ditjenbun, 2019). According to the Coffee and Cocoa Research Center, some Robusta clones are popular to be cultivated by farmers due to their proper traits of well cultivated namely clones BP 42, BP 409, BP 939, BP 308, BP 534, and SA 23 (Hendro, 2012). Clones BP 939 and BP 308 has been suggested as superior clone.

The Robusta coffee, clone BP 308 reportedly has a growth potential of up to 10% better than the Robusta coffee clone BP 939 (Muliasari, 2019). While clone BP 939 has the lowest stomatal density and the highest yield or production potential of 1.4–1.9 tons. ha^{-1} and is vulnerable to parasitic nematodes (Kepmentan, 2017). However, both clones are valuable to grow in small-scale coffee plantations.

In the nursery stage, coffee seedlings are vulnerable to environmental conditions such as nutrient deficiency and drought. The application of organic matter at the nursery must be done to minimize the negative impact in such conditions.

Organic matter, such as waste of banana peel, can be used as liquid organic fertilizer. According to data from BPS (2013), total national banana production in 2012 reached 34.35% of total national fruit production, so the waste of banana peel will be abundant and properly utilized as an organic matter for plant growth. Banana peel contains potassium elements that are useful for improving physiological activities in plants, such as photosynthesis by modulating opening and closing stomata (Masdar, 2003; Amrutha et al., 2007; Hussein et al., 2019), and involvement in enzymatic systems, plant resistance, protein synthesis, and pH regulation (Amrutha et al., 2007).

The method how to use banana peel waste as a useful organic matter for plants is by producing LOM. Several studies showed the application of 40 mL of LOM increased the height of Arabica coffee seedlings 60 days after transplanting (Irawati 2019). Fadhlan's (2015) suggestion that 20 ml of LOM significantly increases plant height, root volume, root dry weight, and shoot dry weight among Robusta coffee seedlings clone BP 939. A significant effect of 50 mL LOM had also been shown by increasing in height, diameter, shoot fresh weight, root fresh weight, and root dry weight of oil palm seedlings (Anhar, 2021).

According to the previous studies above mentioned, the study on the development and physiological responses of Robusta coffee seedlings among various clones and various doses of LOM derived from banana peel waste is required.

Materials and Methods

Plant materials used were three-month-old seedlings of the Robusta coffee clones BP 308 and BP 939, Inceptisol, LOM derived from kepok banana peel waste, EM-4-brown sugar, and NPK fertilizer (16-16-16). Instrument used in present experiment were LOM-making container, analytical scales, 35 x 35 cm polybag, thermal imaging camera (Flir Inc. US), hygrometer, 50% net shade, and chlorophyll meter (Apoogee, UK).

Randomized Block Design was utilized as the experimental design. There were a total of 30 experimental units, with each group consisting of 10 treatments performed three times, so there were 60 research experimental units with 2 plants each. Significantly difference among the data were alalyzed by Duncan Multiple Range Test (DMRT). The 10 treatments in detail as follows:

A = Clone BP 308 + 1,5 g NPK
B = Clone BP 939 + 1,5 g NPK
C = Clone BP 308 + 10 mL.L^{-1}.plant^{-1} LOM
D = Clone BP 939 +10 mL.L^{-1}.plant^{-1} LOM
E = Clone BP 308 + 20 mL.L^{-1}.plant^{-1} LOM
F = Clone BP 939 + 20 mL.L^{-1}.plant^{-1} LOM
G= Clone BP 308 + 30 mL.L^{-1}.plant^{-1} LOM
H= Clone BP 939 + 30 mL.L^{-1}.plant^{-1} LOM
I = Clone BP 308 + 40 mL.L^{-1}. plant^{-1} LOM
J = Clone BP 939 + 40 mL.L^{-1}. plant^{-1} LOM

Measurements parameters: This study has two parameters: morphological parameters such as plant height, leaf number, and chlorophyll index, and physiological parameters such as leaf temperature and stomatal conductance. All parameters were measured three times at 1, 2, and 3 months after transplanting.

Plant height and leaf number were measured by calculating the increase in plant height and leaf number per month. The chlorophyll index was measured by inserting 2nd leaf from above into the cuvette of the chlorophyll meter then the value of the index was recorded. Stomatal conductance was measured by using a porometer (Decagon Device, US Inc.) at the 2nd leaf from above.

All data collected were subjected to analysis of variance and the continue with Duncan multiple range test (DMRT) in SPSS statistical software (IBM Inc.).

Results and Discussion

Generally, LOM banana peel treatment significantly affected plant height increase, leaf number increase, chlorophyll index, and stomatal conductance responses.

The response of plant height increment at the 1st and 2nd MAT was no significant difference among the treatment of doses and clones. At the 3 MAT, the application of 10 mL.L^{-1}.plant^{-1} LOM was better in the plant height increase of D, compared to the G treatment of 30 mL.L^{-1}.plant^{-1} LOM (Table 1). The LOM application tended no significant difference to inorganic fertilizer application i.e., NPK, which means the application of LOM potentially complementary or substitute for inorganic fertilizer at the seedling stage. It is well known that the nutrients of inorganic fertilizers are higher than those of organic fertilizers. The effect of LOM is to improve plant growth due to its micro and macronutrients (Mappanganro, 2018).

Table 1. Response of plant height increment at 1, 2, and 3 MAT among clones and LOA doses

Treatments	Plant Height Increase (cm)		
	1st MAT	2nd MAT	3rd MAT
A	3.3 a	5.7 a	10.1 ab
B	3.4 a	6.6 a	15.7 c
C	2.1 a	4.2 a	8.7 ab
D	3.4 a	4.8 a	10.6 b
E	2.2 a	4.4 a	7.8 ab
F	2.2 a	4.3 a	8.7 ab
G	4.7 a	3.1 a	5.4 a
H	2.8 a	10.6a	7.2 ab
I	3.2 a	5.5 a	9 ab
J	4.6 a	3.6 a	6.2 ab

*Values followed by the same letter within each row are not different at the 0.05 level of significance according to DMRT test.

A similar effect was well as in another growth parameter i.e., leaf number increase (Table 2.). At the 3 MAT clone, BP939 showed a significant difference in leaf number increase between two doses of LOM namely 10 and 20 mL.L^{-1}.plant^{-1} or D and F treatment, others showed no significant difference except in B. Leaf number of plants is correlated to photosynthetic capacity where more increase leaf number has the possible increase in photosynthesis (Permatasari, 2014; Hu et al., 2021).

Table 2. Response of leaf number increment at 1, 2, and 3 MAT among clones and LOA doses

Treatments	Leaf Number Increase (sheet)		
	1st MAT	2nd MAT	3rd MAT
A	2.3 a	4.7 abc	6.7 ab
B	4.0 a	8.3 c	21 c
C	2.7 a	4.3 ab	9.3 b
D	1.7 a	1.3 a	2.3 a
E	1.7 a	3.3 ab	5.3 ab
F	4.3 a	5.3 bc	11 b
G	2 a	3.7 ab	6.3 ab
H	5.3 a	6.3 bc	11.7 b
I	2.7 a	4.3 ab	6.7 ab
J	2.3 a	4.7 abc	8.3 ab

*Values followed by the same letter within each row are not different at the 0.05 level of significance according to DMRT test.

The statistical analysis showed that treating LOM banana peel waste at 1 MAT significantly affected the chlorophyll index of clone BP 939 and

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clone BP 308. Treatment I was higher than C, D, and H treatments, but it was not significantly different from the others (Table 3). This result indicates that the application of LOM of banana peel waste has a positive effect on the chlorophyll index as well as inorganic fertilizers application result. According to Sakiroh (2020), clone BP 308 has a relatively high chlorophyll content. A high chlorophyll index indicates a higher photo-synthetic rate, which will positively affect shoot growth and development (Firdaus et al., 2021).

There are significant effects of LOA among the doses at 1 MAT, where J is higher in chlorophyll index compared to C, D, and H. However it does not differ with the application of inorganic fertilizer. These results indicate fast release of LOM at the first application. Chlorophyll index response among the LOM application at 2 and 3 MAT was no significant difference indicating all doses have a similar effect, however, it was significantly lower compared to inorganic fertilizer application except at 2 MAT of A and J treatment, LOM had a similar effect with A. These indicate that inorganic fertilizer was absorbed by plants slower than LOM i.e. up to 2-3 MAT. The Clone BP 939 had a higher response in absorption of inorganic fertilizer compared to BP 308 (Table 3.) Moreover, inorganic fertilizer is well known to contain higher nutrients e.g., NPK than that LOM. According to Permana (2015), applying N fertilizer affects the chlorophyll index. Marvelia et al. (2006) stated that N nutrients positively affect leaf chlorophyll. Leaves will be better able to absorb sunlight, this helps the process of photosynthesis. Chlorophyll can be formed through N nutrients that are available in plants.

Table 3. Response of chlorophyll index at 1, 2, and 3 MAT among clones and LOA doses

Treatments	Chlorophyll Index		
	1st MAT	2nd MAT	3rd MAT
A	23.1 bcd	32.1 b	58.7 b
B	23.8 bcd	49.9 c	71.4 b
C	13.9 ab	18.3 ab	26.9 a
D	18.4 abc	13.4 a	12.6 a
E	20.1 abcd	16.7 ab	17.7 a
F	25.9 cd	22.7 ab	15.2 a
G	21.8 abcd	19.4 ab	26.2 a
H	11.6 a	15.4 ab	18.7 a
I	30.5 d	21.5 ab	22.8 a
J	20.2 abcd	12.8 a	14.7 a

*Values followed by the same letter within each row are not different at the 0.05 level of significance according to DMRT test.

The results of statistical tests at 1 MAT and 2 MAT showed that all treatments did not significantly affect the value of stomatal conductance of Robusta coffee seedlings in both BP 939 and BP 308 clones (Table 4.). This is a positive response to the application of LOM due to it gives the same response as the application of inorganic fertilizers. According to Arista (2015), a stomatal opening will affect the value of stomatal conductance, meaning that the more open stomata, the higher the conductance value. This opening is influenced by several things, including carbon dioxide, humidity, temperature, wind, light, and leaf water potential (Lestari, 2006; Soleh et al., 2017, 2018).

Table 4. Response of Stomatal Conductance at 1, 2, and 3 MAT among Clones and LOM doses

Treatments	Stomatal Conductance (mmol H_2O $m^{-2}s^{-1}$)		
	1st MAT	2nd MAT	3rd MAT
A	12.1 a	18.6 a	109.6 ab
B	7.6 a	21.6 a	185.7 bcd
C	9.5 a	10.5 a	238.9 d
D	10.4 a	98.8 a	205.7 bcd
E	12.7 a	24.2 a	194.9 bcd
F	8.4 a	141.2 a	282.73 d
G	11.5 a	159.4 a	133 abc
H	11.9 a	57.5 a	233.1 cd
I	9.7 a	98.5 a	73.7 a
J	8.3 a	21.7 a	222.7 cd

*Values followed by the same letter within each row are not different at the 0.05 level of significance according to DMRT test.

At 3 MAT, the treatment of LOM had a significant effect on the stomatal conductance of clone BP 939 and clone BP 308. Treatments C and F were significantly different from treatments A, G, and I but not significantly different from the other treatments. At 3 MAT, the best results were obtained from the treatment of LOM with a dose of 10 mL.L-1.plant-1 (treatment C) for clone BP 308 and a dose of 20 mL.L- 1.plant-1 (treatment F) for clone BP 939 (Table 4.). This shows that applying LOM can positively affect the value of leaf stomatal conductance so that the magnitude is the same as applying inorganic fertilizers. This is due to the effect of LOM application that can modulate opening and closing stomata (Soleh et al., 2018; Hu et al., 2021). According to Jones (1991) & Wijaya (2008), potassium (K) is an essential macro element that plays a role in maintaining

water availability in plants and cell turgor pressure as well as in opening and closing leaf stomata. Plants with sufficient potassium will find it easier to close the stomata and reduce transpiration than plants that lack K (Hu et al., 2013; Nugroho, 2015). Plants with sufficient K elements will increase the transcription of genes related to ethylene synthesis so that the ethylene formed will inhibit abscisic acid activity in stimulating stomatal closure so that the stomata close slowly (Benlloch-Gonzalez et al., 2010)

Conclusion

The application of LOM derived from banana peel has a positive effect on increasing morphological responses of Robusta coffee seedlings of clone BP 308 and clone BP 939 such as in plant height and leaf number, physiological responses, represented by chlorophyll index and stomatal conductance at the 3 months after treatment (MAT). The BP939 was partly better in response to LOM of 10 $mL.L^{-1}.plant^{-1}$ on plant height, the BP308 was partly better in stomatal conductance.

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