Biosaintifika 15 (3) (2023): 441-449 p-ISSN 2085-191X | e-ISSN 2338-7610
Journal of Biology & Biology Education https://journal.unnes.ac.id/nju/index.php/biosaintifika

Application of Rabbit Urine and Manure Based Fertilizer on the Growth of Arabica and Robusta Coffee Seedlings

Sucihatiningsih Dian Wisika Prajanti[1], Christina Litaay[2], Talitha Widiatningrum[3], Dhea Rizky Amelia[4], Dalila Daud[5]

[1]Departmen of Economic Development, Faculty of Economics and Business, Universitas Negeri Semarang, Semarang City, Indonesia
[2] UPT Marine Biota Conservation Center, National Research and Innovation Agency, Jakarta, Indonesia
[3]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang City, Indonesia
[4]Departmen of Management, Faculty of Economics and Business, Universitas PGRI Semarang, Semarang City, Indonesia
[5]Departmen of Accountancy, Faculty of Accountancy, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

*Corresponding E-mail: dianwisika@mail.unnes.ac.id

Submitted: 2023-09-13. Revised: 2023-11-12. Accepted: 2023-12-12.

Abstract. Coffee farming demands substantial amounts of fertilizer. Furthermore, the expensive cost of chemical fertilizers prompt coffee growers to seek alternative remedies. One emerging solution is the utilization of organic fertilizer. This study aims to assess the impact of organic fertilizer, specifically made from rabbit manure and urine, on the growth of Arabica and Robusta coffee seedlings. The experiment focused on the context of coffee cultivation in Temanggung Regency, comparing the effects with goat manure fertilizer. The method was initiated by producing organic fertilizer, encompassing rabbit manure, goat manure, and rabbit urine. Then, the fertilizer was applied to Arabica and Robusta seedlings. The research employs quantitative and descriptive analyses. Quantitative data encompasses the nutrient content of each fertilizer and soil, plant height, leaves number, and stem diameter. Descriptive analysis involves the overall performance evaluation. The application of rabbit manure and urine as fertilizers to Arabica and Robusta coffee seedlings yields positive outcomes, i.e. enhancing plant height, leaves number, and seedling diameter. Among the tested organic fertilizers, rabbit urine notably influenced the plant height, leaves number, and stem diameter of both seedlings. The performance of the rabbit urine treatment exhibited healthier attributes compared to those without any fertilizer, such as sturdy leaves and robust stems. Additionally, the root systems of the untreated plants appear less vigorous with sparser root hairs.

Keywords: Robusta coffee; Arabica coffee; Organic Fertilizer; Rabbit Urine and Manure

How to Cite: Prajanti, S. D.W., Litaay, C., Widiatningrum, T., Amelia, D. R., & Daud, D. (2023). Application of Rabbit Urine and Manure Based Fertilizer on the Growth of Arabica and Robusta Coffee Seedlings. *Biosaintifika: Journal of Biology & Biology Education, 15*(3), 441-449.

DOI: http://dx.doi.org/10.15294/biosaintifika.v15i3.48027

INTRODUCTION

The agricultural industry plays a crucial role in the national economy by significantly contributing to the Gross Domestic Product (GDP) and serving as a primary source of food for the nation (Amisan et al., 2017). Additionally, this sector greatly influences the country's currency by export engagement (Zakaria et al., 2017). Predominantly, coffee stands out as a promising agricultural product for further development. This happens because there is an increase in world demand for coffee from year to year, due to the culture of hanging out in cafes by young people and businesses (ICO, 2023).

However, it turns out that Indonesia is the world's fourth-largest coffee-producing country after Brazil, Vietnam, and Colombia (Wibowo and Ayu, 2023). Indonesian coffee is produced by three different sectors consisting of small farming communities, government companies, and private companies (Ibnu, 2020). Temanggung Regency, located in Indonesia's Central Java Province, stands out as a region with the potential for coffee production. In Temanggung, there are two types of coffee, namely Arabica and Robusta. According to Central Bureau of Statistic (BPS) data of Temanggung Regency (2021), among all Temanggung's districts, Ngadirejo is recorded as the highest producer of arabica coffee, yielding

227.54 tons, along with Tretep, which produced 208.80 tons. Likewise, when it comes to robusta coffee production, Bejen and Ngadirejo Districts take the lead, producing 1978.29 tons, followed by Kandangan District with a total production of 1945.13 tons.

Coffee farming businesses in Temanggung Regency are mostly managed by small farmers, so there is a necessity to be optimized in the future as a business attraction to produce higher outcomes and encourage coffee productivity and competitiveness. The most influential factor for the cultivation is fertilizer. But then, most of the farmers apply conventional cultivation by using large amounts of chemical fertilizers. Only a few of them apply organic systems, resulting in environmental damage. In fact, fertilization is a key factor in the growth of coffee seedlings, as it ensures the juvenile achieves sufficient nutrition (Carréra et al., 2023). However, to maintain soil fertility, fertilizer is needed in larger amounts to manage the biological, chemical, and physical quality of it (Amir et al., 2017). Thus, producing coffee requires very large amounts of chemical fertilizer, and increases the high costs of production. A different remedy is required efficiently (Rahmah et al, 2022). One elucidation that has emerged is to use organic fertilizer, one of which is manure (Audry and Djuwendah, 2018; Batoro et al, 2017). Furthermore, switching to green coffee cultivation will significantly reduce environmental damage caused by coffee production activities. Organic cultivation systems that avoid chemicals represent ongoing green cultivation that is currently widely practiced in agricultural production (Biernat-Jarka and Trebska, 2018).

Purnama et al. (2023) conducted research that confirmed pig manure-based liquid organic fertilizer had a positive effect on Arabica coffee seedlings. Yulianti et al. (2022), in research on spinach plants, found that chicken manure gave the best results. Meanwhile, Delita's (2023) research on sugar cane plants shows that cow manure affects the number of leaves. Tsaniyah & Daesusi (2020) concluded that chicken manure is the best for growing red chilies, compared to duck, cow, and goat manure. Sutrisno & Yusnawan (2018) attested manure effect on Mungbean secondary metabolite.

However, previous research has not considered the use of organic fertilizer derived from rabbit feces and urine. This study chose both because the urea content in rabbit feces and urine is higher than in other livestock manure (Mutai et al., 2020). Furthermore, the farmers in Temanggung Regency frequently give goat manure supplementation to the coffee plantation. Therefore, the aim of this research is to analyze the effect of organic fertilizer made from rabbit manure and urine on the growth of arabica and robusta coffee seedlings, with a focus on the case of coffee farming in Temanggung Regency with goat manure fertilizer as the comparison.

METHODS

Location and time

The research was carried out in Ngadirejo District, Temanggung Regency, Indonesia. The district is 19 Km away from Temanggung City. The wide area is 5,331 Ha, with 1,505 Ha of paddy field and 3,826 Ha of non-paddy land. The district consists of 20 villages. The research was done at Tegalrejo village at 7°15'27.0"S 110°00'49.5"E where the coffee plantation seems to be prosperous, and the Jumprit National Park is located with the altitude was 2,000 m above sea level.

The research was done during the dry season from June to November 2023. The temperature was around 25.9-27.6 ^{0}C and the humidity was around 65-67 % with an average rainfall of around 1,500 mm/year.

Preparation

There was some preparation of the fertilizer. The goat manure was made by using 10 kg of goat feces, 10 mL EM4, 10 mL molasses, and 1 L water. The fermentation of all components was done for 2 months in a compost bag by regularly shifting the compound. The rabbit manure was made by a similar method, while the rabbit urine was made by swapping the 10 kg feces into 5 L urine and 5 kg feces. The finished fertilizer was then analysed for organic C, total N, phosphorus, and potassium content in triply at the chemical laboratory of agricultural research and development centre BPTP, Central Java, Indonesia.

The planting media were soil, husk charcoal, and fertilizer in the composition of 1 : 1 : 1 in w : w: w. While for no fertilizer then the composition was soil and husk charcoal only (1 : 1). The soil was topsoil that had been thoroughly sieved. Husk charcoal was obtained by burning rice husks until they became charcoal. The fertilizers were the above fertilizer in a separate treatment. The polybags for the medium were 15 cm wide, 25 cm high, and 0.08 mm thick.

The seeds employed were Arabica and Robusta coffee seeds at the age of 4 months, with prior consistent initial growth conditions, i.e., the heights were around 10 cm, the leaves number were around 3, and the stems' diameter was around 1 cm.

Treatment

The design used in this research was 2 factorial randomized complete block design (RCBD) with three replications. The first factor was the type of coffee which consisted of Arabica and Robusta. The second factor was the fertilizer treatment consisting of rabbit manure (Kk), rabbit urine (Uk), goat manure (Kb), and without fertilizer as the control (Ka). There were 3 plants for each treatment, and thus there were 24 plants in total.

The seedlings were watered daily by using an irrigation hose. Weeding is performed to eliminate grass and other plants that could act as pests to the crops. Replacing dead, damaged, or abnormally growing seedlings with the prepared ones was also accomplished during cultivation.

Data collection

The data taken consists of plant height, number of leaves, and stem diameter. With an observational of the whole performance and the root. Plant height was measured from the base of the stem to the tip by using a centimeter ruler. Stem diameter measurements were carried out by using a compass to shove it by clamping it on the stem (1 cm above the base of the stem). The measurement of plant height, number of leaves, and stem diameter was done every 2 weeks (14 days) until 140 days after planting (dap).

Data analysis

The data of fertilizer and soil content, final stem height, final leaves number, and final stem diameter underwent analysis by a 4x2 factorial ANOVA at a confidence level of 95%. If the ANOVA identified significance differences ($P < 0.05$) among treatments, the DMRT test was employed for mean separation at a significance level of 0.05.

RESULTS AND DISCUSSION

Fertilizer analysis

The examination of fertilizers verified the presence of carbon, nitrogen, phosphorus, and potassium as outlined in Table 1. Among all the fertilizers tested, rabbit urine exhibited the most favourable nutrient content, displaying notable differences compared to other fertilizers. A level below, there was rabbit manure with notably high carbon, nitrogen, and potassium. Conversely, the carbon and phosphorus content in goat manure wasn't significantly different from the soil used as an additional medium. In sort, there was a possibility that the additional of rabbit urine elevated the nutrient content, since the data of Table 1 display a high carbon, nitrogen, phosphorus, and potassium of the given fertilizer. Urine has been proved to contain a lot of urea (Ajiboye et al., 2022). This urea provides a large supply of nitrogen to plants. However, too high nitrogen deterred the plant growth (Sene et al., 2019). Therefore, in this study, at the time of manufacture, urine was not given as a whole fertilizer component, but was mixed with rabbit droppings. Thus, from the data it appears that there was a balance of nutrient components which ultimately provides excellent growth of seedlings' height.

Table 1. Nutrient content of the fertilizers and soil.

The prepared fertilizers and soil	Chemical Indicators			
	C organic (%)	N Total (%)	P_2O_5 (%)	K_2O (%)
Rabbit manure (Kk)	64.33	1.47	0.09	0.29
Rabbit urine (Uk)	79.54	1.89	0.15	0.34
Goat manure (Kb)	50.98	1.44	0.04	0.25
Topsoil (Ka)	45.98	1.29	0.02	0.15

Plant Height

As in Figure 1, the heights of each plant increased in each 14 dap. Briefly, rabbit urine (Uk) fertilizer treatment showed the uppermost plant height growth for both Arabica and Robusta coffee seedlings. Nevertheless, the growth of plants in all treatments appears to follow a linear phase of the growth curve, likely because the utilized plants were seedlings that were still in the initial stage of growth and had not reached their maximum stage yet. Juvenile plants mostly counter a static expansion in the form of linear growth (Brüllhardt et al., 2020).

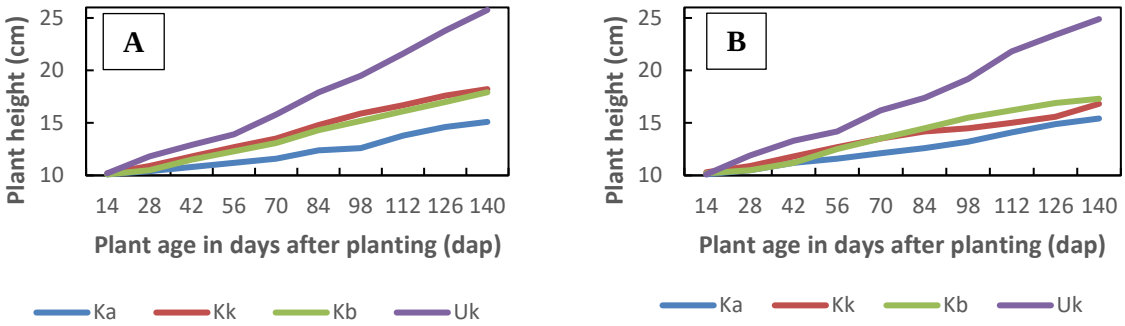

Figure 1. The curve of Arabica (A) and Robusta (B) coffee plants' height after treatment of media with no fertilizer (Ka), with rabbit manure (Kk), with goat manure (Kb), and with rabbit urine (Uk).

The final height ANOVA analysis as in Table 2 proved the significant difference of this Uk treatment among others. However, fertilizer from rabbit manure (Kk) and goat manure (Kb) indicated similar pattern on Arabica coffee seedling, while on Robusta, these fertilizers gave practically comparable plant height as given by ANOVA analysis. The control plant grew even with a minimal fertilizer because the used soil was a topsoil around the coffee plantation with high coffee leaf litter, and thus content adequate source of nutrients as in Table 1. Some leaves fell to the ground and become a natural compost of the topsoil which manage a good environment for beneficial microorganisms having mutual relationship to the plant (You et al., 2020). Furthermore, the coffee planting area is a national park area with many forest plants which protect the occurrence of erosion of topsoil layer nutrients. As research conducted in the Atlanta Forest biome to compare sustainable and degraded forests, that found no significant difference between the two types of forests in terms of soil nutrients, thus proving that lowland forests are relatively resistant to deforestation and leaching (Safar et al., 2019).

Table 2. The final plant height (cm) of Arabica and Robusta seedlings after treatment of fertilizer of rabbit manure (Kk), goat manure (Kb), rabbit urine (Uk), and without fertilizer (Ka).

	Final plant height (cm)			
	Ka	Kk	Kb	Uk
Arabica	15.10^{a}	18.22^{b}	17.92^{b}	25.76^{c}
Robusta	15.42^{a}	16.82^{ab}	17.30^{ab}	24.89^{c}

Different indexes next to values indicate a statistically significant difference in means at the $p<0.05$ level as by ANOVA analysis of RCBD.

Number of Leaves

As in Figure 2, the number of Arabica coffee seedling leaves for the treatment without fertilizer did not appear to increase rapidly and even tends to stagnate. However, the three fertilizer treatments for Arabica coffee leaves showed a growth curve pattern that tended to overlap. The ANOVA of the final Arabica seedlings' number of leaves bared no significant different (Table 3). Meanwhile, even if the Robusta seedlings' height growth was inferior, the leaf growth performed the reverse. Robusta coffee seedling without fertilizer tend to be able to survive and show a rise in leaves number. The ANOVA for Robusta seedlings' final leaves number gave no different consequences for the rabbit manure (Kk) and rabbit urine (Uk) treatments but gave significant differences to goat manure (Kb) and no fertilizer (Ka) treatments.

Leaves' growth is not only related to the number of leaves, but there is also domestic growth of the leaves, such as chlorophyll and lignin content which functions as a morphological defence of the leaves from the surrounding environment, from insect's attacks and diseases (Kumar & Dwivedi, 2020; Zou et al., 2020). The insects prefer to attack the leaves rather than coffee stem due to the saggy structure (Mendesil, 2019). Therefore, it is received that the growth in the number of Arabica coffee leaves for the three fertilizer treatments tends to be the same, even though the nutrient content in Table 1 is different. A different pattern of Robusta coffee is also acceptable since both coffee plants have different phenotype and genotype. Robusta coffee has prominent veins, which means there is a resettlement of stem growth to the leaves, this is what is likely to make the growth of Robusta leaves better than Arabica leaves (Patil et al., 2023).

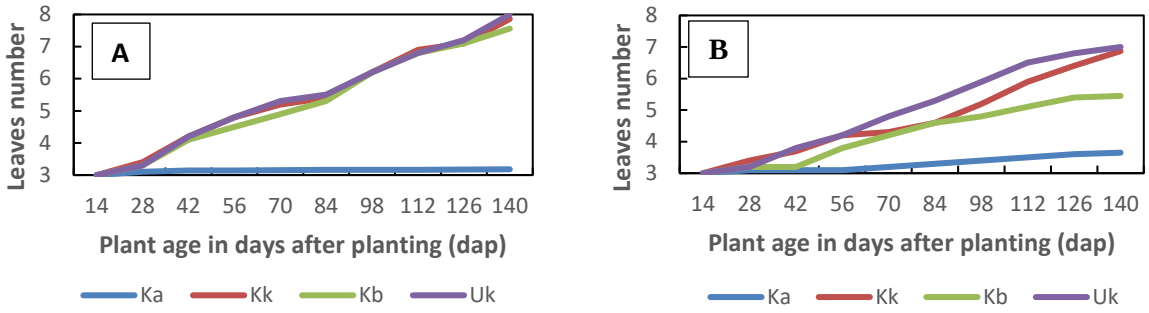

Figure 2. The curve of Arabica (A) and Robusta (B) coffee plants leaves number after treatment of media with no fertilizer (Ka), with rabbit manure (Kk), with goat manure (Kb), and with rabbit urine (Uk).

Table 3. The final leaves number of Arabica and Robusta seedlings after treatment of fertilizer of rabbit manure (Kk), goat manure (Kb), rabbit urine (Uk), and without fertilizer (Ka).

	Final leaves number			
	Ka	Kk	Kb	Uk
Arabica	3.18[a]	7.86[c]	7.56[c]	8[c]
Robusta	3.65[a]	6.87[b]	5.45[b]	7[c]

Different indexes next to values indicate a statistically significant difference in means at the $p<0.05$ level as by ANOVA analysis of RCBD.

Stem Diameter

As in Figure 3, the treatment of rabbit urine (Uk) gave rise to the finest stem diameter growth of Arabica and Robusta coffee. However, the ANOVA (Table 4) of the final data of the increase stem diameter of Arabica coffee displayed no significant difference of rabbit manure (Kk) and rabbit urine (Uk) results, and both gave thicker stem than goat manure (Kb) and no fertilizer treatment (Ka). ANOVA of the Robusta seedlings presented significantly different increase in stem diameter of the rabbit urine (Uk) to the other treatment. Rabbit urine still gave a magnificent result of the growth of the stem.

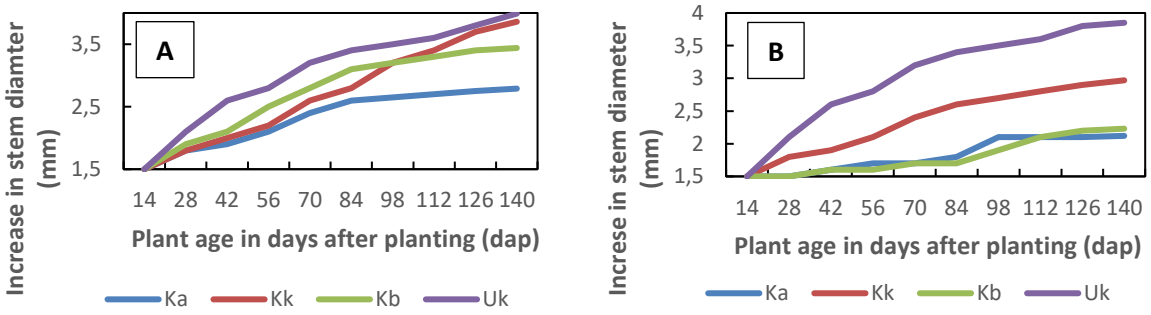

Figure 3. The curve of Arabica (A) and Robusta (B) coffee plants increase in stem diameter after treatment of media with no fertilizer (Ka), with rabbit manure (Kk), with goat manure (Kb), and with rabbit urine (Uk)..

Table 4. The final increase of stem diameter (mm) Arabica and Robusta seedlings after treatment of fertilizer of rabbit manure (Kk), goat manure (Kb), rabbit urine (Uk), and without fertilizer (Ka).

	Final increase of stem diameter (mm)			
	Ka	Kk	Kb	Uk
Arabica	2.79[a]	3.86[b]	3.44[ab]	3.99[b]
Robusta	2.12[a]	2.97[ab]	2.23[a]	3.85[b]

Different indexes next to values indicate a statistically significant difference in means at the $p<0.05$ level as by ANOVA analysis of RCBD.

Figure 4. Comparison of the Robusta seedlings' performance of non-fertilizer treatment (Ka), left and treatment of rabbit urine (Uk), right.

As in Figure 4. the plant of rabbit urine (Uk) treatment appears to be healthier than no fertilizer treatment (Ka), as indicated by a shiny and rigid leaves, and sturdy stem. The plants of no fertilizer treatment experienced leaves that started to turn yellow, this was caused by the nutrient deficiency. Plants supplied by sufficient nitrogen will form wider leaves and higher chlorophyll content and affect the process of forming sufficient assimilates/carbohydrates to configure vigorous vegetative organs (Surya et al., 2017; Arlen & Fauzana, 2018; Lukman et al., 2021; Purwanto & Suharti, 2021). According to Puspita & Khumaira (2020), organic compost play an important role in increasing soil fertility, especially in soil that is heavily fertilized with inorganic fertilizers, thereby reducing the quality of the soil structure. This is in accordance with the statement by Makmur & Kharim (2020) which states that by adding manure, the physical, chemical, and biological properties of the soil will be in good condition, especially soil that is damaged and detrimental. Under good conditions, plants can grow well and produce high yields. The addition of fertilizer to the soil stimulates soil microorganisms to increase their activity, even the amount of energy sources needed by microorganisms for their activity increases, which has an impact on increasing the ability of plants to absorb nitrogen and phosphorus elements (Arlen & Fauzana, 2018; Falahudin & Harmeni (2016).

Figure 5. Comparison of the root of coffee of non-fertilizer treatment (Ka), left and treatment of rabbit urine (Uk), right.

This can also be seen from the plant roots where the plant roots in no fertilizer treatment (Ka) have less compact root hairs. The nitrogen for plant growth was not optimally supplied. Arabica and robusta coffee plant seeds responded better to treatment with fertilizer from rabbit urine. This is possible because the nutrient content in rabbit urine fertilizer (Uk) was higher than the other fertilizer as in Table 1. Recent research of rabbit urine application for coffee seedlings of Meranti Liberoid Varieties and POC on Arabica coffee seedlings gave equivalent results (Luthfi et al., 2023; Humaida, 2023). According to Rosniawaty et al (2018), when compared with other manure, fertilizer from rabbit urine contained three times more nitrogen and urea than other livestock. Because of its remarkably high nitrogen content, rabbit urine presents itself as a highly prospective fertilizer. Nitrogen (N) plays a pivotal role in plant development by participating in crucial processes like growth, leaf expansion, and the generation of biomass. Multiple essential plant compounds, including amino acids, chlorophyll, nucleic acids, ATP, and phytohormones, contain nitrogen as a fundamental component, necessary for various biological processes. These processes encompass

carbon and nitrogen metabolism, photosynthesis, and protein synthesis (Leghari et al., 2016).

Hence, the findings from this study hold significant benefit in preserving soil fertility in an environmentally sustainable and cost-effective manner. Implementing the fertilizer can enhance crop worth by curbing input expenses. Assessments of the initial investment, yearly costs, annual benefits, and key parameters, such as the B/C ratio, indicate that using rabbit urine fertilizer was more economically viable than not using any fertilizer or resorting to inorganic options in nurturing Arabica and Robusta coffee. These outcomes resonate with Guo et al.'s findings (2015), affirming that livestock manure delivers superior economic advantages in enhancing corn growth and yield compared to conventional methodologies.

As a closing remark, the study's discoveries offer a novelty perspective on Arabica and Robusta coffee plantations, particularly in the management of seedlings through the application of rabbit urine as a natural nutrient source. This fertilizer demonstrates its positive impact on the growth of coffee seedlings, a crucial phase in coffee cultivation. By fostering the growth of resilient seedlings, there's potential for enhancing the overall development of the coffee plants.

The study indicates an advantage for conventional coffee cultivation, which is the primary source of coffee in Temanggung regency and Indonesia, that by intense rabbit urine fertilizer application, then there's a potential to lower production expenses, thereby reducing overall costs. Nevertheless, it remains crucial to address the limited accessibility of rabbit urine, as not all farms have easy access to this resource.

CONCLUSION

Application of rabbit manure and urine as fertilizers to Arabica and Robusta coffee seedlings yields favorable outcomes, i.e. enhancing plant height, leaf count, and seedling diameter. Rabbit urine exhibits positive impact on the growth of coffee seedlings, a practice that have not been extensively utilized among coffee farmers. Additionally, the application of organic fertilizer derived from rabbit urine exerts a stronger influence on Arabica coffee compared to Robusta coffee. However, this study was confined to the Temanggung Regency area and specifically targeted coffee plants for the organic fertilizer application. Future research endeavors should encompass a broader research scope for comparative purposes, involving a wider range of subjects beyond coffee plants.

REFERENCES

Ajiboye, T. O., Ogunbiyi, O. D., Omotola, E. O., Adeyemi, W. J., Agboola, O. O., & Onwudiwe, D. C. (2022). Urine: Useless or useful "waste"?. *Results in Engineering*, 100522.

Amir, NH, Rasmikayati, E., & Saefudin, BR (2017). Analysis of coffee farming in the Giri Selamat Forest Farmer Group, Giri Mekar Village, Bandung Regency. Galuh Agroinfo Student Scientific Journal, 3(3), 472-479.

Amisan, RE, Laoh, OEH, & Kapantow, GH (2017). Analysis of Coffee Farming Income in East Purwerejo Village, Modayag District, East Bolaang Mongondow Regency. Agri-Socioeconomics, 13(2A), 229-236.

Arlen, F., & Fauzana, H. (2018). The effect of administering doses of vermicompost and NPK fertilizer on the growth of Arabica coffee (Coffea arabica. L) seedlings. Student Online Journal (JOM) in Agriculture, 6, 1-13.

Audry, RJ, & Djuwendah, E. (2018). Analysis of Java Preanger Coffee Farming Income in the Margamulya Farmer Group, Margamulya Village, Pengalengan District, Bandung. Journal of Agricultural and Animal Science, 6(1), 31-38.

Batoro, J., Indriyani, S., & Yanuwiadi, B. (2017). Ethno-ecology of Komplangan Field of the Bromo, Tengger, and Semeru Area in East Java: a qualitative approach. *Biosaintifika: Journal of Biology & Biology Education*, *9*(1), 41-48.

Biernat-Jarka, A., & Trębska, P. (2018). The importance of organic farming in the context of sustainable development of rural areas in Poland. *Acta Scientiarum Polonorum. Oeconomia*, *17*(2), 39-47.

Brüllhardt, M., Rotach, P., Bigler, C., Nötzli, M., & Bugmann, H. (2020). Growth and resource allocation of juvenile European beech and sycamore maple along light availability gradients in uneven-aged forests. *Forest Ecology and Management*, *474*, 118314.

Carréra, J. C., Resende, T. B., Vicente Campos, A. A., de Souza, R. R., de Oliveira, I. M. M., Alves Ribeiro, C. and Mori, F. A. (2023). Anatomic characteristics of branches related to the vegetative growth of coffee tree (Coffea arabica L., Rubiaceae) under nutritional variation. *Journal of Plant Nutrition*, *46*(19), 4594-4605.

Delita, K. (2023). Effect of Type and Dosage of

Organic Fertilizer on the Growth of Robusta Coffee (Coffea Robusta L.) Seedlings in Polybags. Agriwana Journal of Agriculture and Forestry, 1(1), 1-10.

Falahudin, I., & Harmeni, L. (2016). The effect of organic fertilizer from coffee skin waste (Coffea arabica L.) on the growth of coffee seedlings. Bioscience: Journal of Education, 2(2).

Guo, L., Wu, G., Li, C., Liu, W., Yu, X., Cheng, D., & Jiang, G. (2015). Vermicomposting with maize increases agricultural benefits by 304%. *Agronomy for sustainable development*, *35*, 1149-1155.

Hayata, H., Marpaung, R., & Putri, A. B. (2023). The Effect of Providing Various Types of Manure on the Growth of Robusta Coffee (Coffea canephora L) Seedlings in Ultisol Soil in Polybags. Journal of Agricultural Media, 8(2), 177-182.

Humaida, S., Ariviana, A., Fisdiana, U., & Cahyaningrum, D. G. (2023, September). The Effect of Liquid Organic Fertilizer (POC) on the Growth of Arabica Coffee (Coffea arabica L.) Seedlings. In Agropross: National Conference Proceedings of Agriculture (pp. 215-226).

Ibnu, M. (2020). Toward a more sustainable coffee production: the implementation capacity of Indonesian standard coffee. *Pelita Perkebunan*, *35*(3), 212-229.

International Coffee Organization (ICO). World Coffee Consumption. 2021. Available online: https://ico.org/prices/new-consumption-table.pdf (accessed on 1 June 2021).

Kumar, P., & Dwivedi, P. (2020). Lignin estimation in sorghum leaves grown under hazardous waste site. *Plant Archives*, *20*(2), 2558-2561.

Leghari, S. J., Wahocho, N. A., Laghari, G. M., HafeezLaghari, A., MustafaBhabhan, G., HussainTalpur, K., ... & Lashari, A. A. (2016). Role of nitrogen for plant growth and development: A review. *Advances in Environmental Biology*, *10*(9), 209-219.

Lukman, L., & Kusrianty, N. (2021). Combination of Use of Water Hyacinth Compost (Eichhornia Crassipes) with Chicken Manure on the Growth Rate of Robusta Coffee Plant Seedlings (Coffea canephora). JST (Journal of Science and Technology), 10(2), 200-210.

Lukman, L., & Kusrianty, N. (2021). Combination of Use of Water Hyacinth Compost (Eichhornia Crassipes) with Chicken Manure on the Growth Rate of Robusta Coffee Plant Seedlings (Coffea canephora). JST (Journal of Science and Technology), 10(2), 200-210.

Luthfi, AH, Rosniawaty, S., Anjarsari, IRD, & Ariyanti, M. (2023). The Effect of Cow Manure and Rabbit Urine Concentration on the Growth of Meranti Liberoid Coffee Seedlings. Paspalum: Agricultural Scientific Journal, 11(2), 348-354.

Makmur, M., & Karim, H. A. (2020). The effect of various POC doses resulting from biogas fermentation on the growth of Arabica coffee (Coffea arabica (L.) Lini S 795) seedlings. Agro Bali: Agricultural Journal, 3(2), 220-228.

Makmur, M., & Karim, HA (2020). The effect of various POC doses resulting from biogas fermentation on the growth of Arabica coffee (Coffea arabica (L.) Lini S 795) seedlings. Agro Bali: Agricultural Journal, 3(2), 220-228.

Mendesil, E. (2019). Insect pests of coffee and their management in Ethiopia: a review. *Trends Entomol*, *15*, 23-34.

Mutai, P. A. (2020). The potential use of rabbit urine as a bio fertilizer foliar feed in crop production. Africa Environmental Review Journal, 4(1), 138-147.

Patil, S., Shankar, S. R., & Murthy, P. S. (2023). Impact of different varieties and mature stages on phytochemicals from Coffea arabica and Coffea robusta leaves. *Biochemical Systematics and Ecology*, *110*, 104699.

Purnama, R., Fadli, F., & Febriana, R. (2023). The Effect of Providing Organic Materials (Manure) and NPK Fertilizer on Coffee Nurseries in Central Aceh Regency. Biram Samtani Science, 7(1), 46-52.

Puspita, D. E., & Khumaira, K. (2020). The influence of the type of organic fertilizer on the cultivation of coffee plants (Coffee sp). Agrista Journal, 24(1), 36-39.

Purwanto, P., & Suharti, W. S. (2021). Nutrient uptake, chlorophyll content, and yield of rice (Oryza sativa L.) under the application of PGPR consortium. *Biosaintifika: Journal of Biology & Biology Education*, *13*(3), 336-344.

Rahmah, D. M., Putra, A. S., Ishizaki, R., Noguchi, R., & Ahamed, T. (2022). A Life Cycle Assessment of Organic and Chemical Fertilizers for Coffee Production to Evaluate Sustainability toward the Energy–Environment–Economic Nexus in Indonesia. *Sustainability*, *14*(7), 3912.

Rosniawaty, S., Ariyanti, M., Sudirja, R., Mubarok, S., & Saragih, EW (2018). Response of young coffee plants to the application of different types of organic material. Agrosintesa Journal of Agricultural Cultivation Science, 1(2), 71-77.

Rosniawaty, S., Ariyanti, M., Sudirja, R., Mubarok, S., & Saragih, E. W. (2018). Response of young

coffee plants to the application of different types of organic material. Agrosintesa Journal of Agricultural Cultivation Science, 1(2), 71-77.

Safar, N. V. H., Magnago, L. F. S., Rolim, S. G., & Schaefer, C. E. G. R. (2019). Atlantic Forest topsoil nutrients can be resistant to disturbance and forest clearing. *Biotropica*, *51*(3), 342-354.

Sene, M., Hijikata, N., Ushijima, K., & Funamizu, N. (2019). Application of human urine in agriculture. *Resource-Oriented Agro-sanitation Systems: Concept, Business Model, and Technology*, 213-242.

Surya, J. A., Nuraini, Y., & Widianto, W. (2017). Study of soil porosity when applying several types of organic materials in robusta coffee plantations. Journal of Soils and Land Resources, 4(1), 463-471.

Surya, JA, Nuraini, Y., & Widianto, W. (2017). Study of soil porosity when applying several types of organic materials in robusta coffee plantations. Journal of Soils and Land Resources, 4(1), 463-471.

Sutrisno, S., & Yusnawan, E. (2018). Effect of manure and inorganic fertilizers on vegetative, generative characteristics, nutrient, and secondary metabolite contents of mungbean. *Biosaintifika: Journal of Biology & Biology Education*, *10*(1), 56-65.

Central Bureau of Statistics (BPS). (2021). Temanggung Regency Plantation Production. 17 December 2023, https://temanggungkab.bps.go.id/statictable/2021/12/08/524/produksi-perkebunan-menurut-kecamatan-dan-jenis-tanaman-ton-di-kabupaten-temanggung-2019-dan-2020.html

Tsaniyah, I., & Daesusi, R. (2020). The effect of giving coffee grounds as organic fertilizer on the growth of cayenne pepper plants (Capsicum frutescens). Pedago Biology: Journal of Biology Education and Learning, 8(1), 58-63.

Wibowo, R. P., & Ayu, S. F. (2023). Analysis of indonesian coffee export demand in the united states using the aids model. *International Journal of Economic, Business, Accounting, Agriculture Management and Sharia Administration (IJEBAS)*, *3*(3), 820-827.

You, Y., Xu, H., Wu, X., Zhou, X., Tan, X., Li, M., ... & Huang, X. (2020). Native broadleaf tree species stimulate topsoil nutrient transformation by changing microbial community composition and physiological function, but not biomass in subtropical plantations with low P status. *Forest Ecology and Management*, *477*, 118491.

Yulianti, M., Sarman, S., & Buhaira, B. (2022). Growth Response of Liberica Coffee Seedlings (Coffea liberic W. Bull Ex Hiern) to the Application of Cow Manure in Polybags. Agroecotania Journal: National Publication of Agricultural Cultivation Science, 5(2), 23-34.

Yusnidar, J., Fitria, D., & Fajri, M. (2023). The Effect of Providing Organic Fertilizer from Coffee Skin Waste and Coffee Grain Washing Water on the Growth of Coffee Plant Seedlings (Coffea arabica L.). Biofarm: Agricultural Scientific Journal, 19(2), 395-402.

Zakaria, A., Aditiawati, P., & Rosmiati, M. (2017). Arabica coffee farming development strategy (case of coffee farmers in Suntenjaya Village, Lembang District, West Bandung Regency, West Java Province). Journal of sociotechnology, 16(3), 325-339.

Zou, W., Zhu, G., Cai, Y., Vilmi, A., Xu, H., Zhu, M., ... & Qin, B. (2020). Relationships between nutrient, chlorophyll a and Secchi depth in lakes of the Chinese Eastern Plains ecoregion: Implications for eutrophication management. *Journal of environmental management*, *260*, 109923.