Acta Solum 4, Number 1 (November 2025), 57–62. DOI: 10.20527/actasolum.v4i1.3523
http://jtam.ulm.ac.id/index.php/actasolum e-ISSN: 2987-5145

The Effect of Liquid Organic Fertilizer from Tofu Factory and Local Microorganisms from Banana Stems of Ultisols

Siti Nurul Aidil Fitri*, Adipati Napoleon, Agus Hermawan, Bakri, Karinda Dwi Paserena, Moch Aziz Pratama

Soil Science Study Program, Faculty of Agriculture, Sriwijaya University, Jl. Raya Palembang – Prabumulih KM 32, Ogan Ilir Regency, South Sumatra 30862

*Correspondence author email: gadis_salman@yahoo.co.id

Article Information

Received October 06th 2025
Accepted January 02nd 2026
Published January 25th 2026
Online January 25th 2026

Keywords:

Banana stems; Liquid organic fertilizer; Tofu factory liquid waste; Ultisol

Abstract

Ultisol is a type of soil that requires processing before agricultural activities can be carried out due to its acidic pH and low nutrient content, necessitating proper treatment. Processing that can be done is by applying liquid organic fertilizer to Ultisol, as it provides nutrients according to plant needs and increases soil fertility. This study aims to understand the effect of the application of liquid organic fertilizer from tofu factory waste and local microorganisms from banana stems on N, P, K, and soil C/N ratio in Ultisols, and find out the best dosage of liquid organic fertilizer from tofu factory waste in increasing Soil N, P, K values and C/N ratio in Ultisols. This research activity started from July to September 2024. This study employed a Completely Randomized Design (CRD) with 6 treatments and 4 replicates, resulting in 24 experimental units. The results showed that the liquid organic fertilizer treatment had a significant effect on available K levels and had no significant effect on total N, available P, and the C/N ratio of the soil in Ultisols. The best value obtained in the liquid organic fertilizer treatment was at a dose of 500 ml, which had an total N value of 0.19%, available P of 24.26 mg kg^{-1}, available K of 1.60 cmol kg^{-1}, and a soil C/N ratio of 15.27. Based on this research, it is suggested that to increase the availability of N, P, and K soil nutrients, it is necessary to provide liquid organic fertilizers with inorganic N, P, and K fertilizers.

1. Introduction

Ultisols are the most extensive suboptimal dryland soil type in Indonesia, covering approximately 45,794,000 ha or about 25% of the country's total land area. These soils are characterized by several major constraints, including high soil acidity (average pH < 4.50), high aluminum (Al) saturation, low macronutrient availability—particularly phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg)—and low organic matter content (Gusnidar et al., 2019). Despite these limitations, Ultisols have considerable potential for dryland agricultural development. However, their utilization remains challenging because their inherent soil properties can inhibit plant growth, especially food crops, if not managed properly (Pasang et al., 2019)

One approach to improving soil fertility in Ultisols is the application of liquid organic fertilizer (LOF). This type of fertilizer has the advantage of supplying nutrients in forms that are readily available to plants and in accordance with their nutritional requirements (Putra and Ratnawati, 2019). High-quality LOF contains essential macronutrients, particularly nitrogen (N), phosphorus (P), and potassium (K), as well as organic matter, which are required by plants in large quantities (Widyabudinigsih et al., 2021). In addition, LOF can be produced using locally available organic waste materials, such as tofu factory liquid waste.

According to Rasmito et al. (2019), wastewater generated from tofu production still contains substantial amounts of organic matter, including proteins, carbohydrates, and fats, making it a potential source of LOF. Tofu factory liquid waste reportedly contains 1.24% N, 5.54% P_2O_5, 1.34% K_2O, and 5.803% organic carbon, all of

which are essential nutrients that can help improve soil fertility and reduce soil acidity. Nutrients in fermented tofu wastewater, when used as LOF, can be readily absorbed by plants (Marian et al., 2019).

The application of organic fertilizers in agricultural soils serves multiple functions, including supplying essential nutrients such as N, P, and K for plant uptake and reducing the soil C/N ratio. The nutrient content of tofu wastewater is particularly beneficial for Ultisol soils, which are generally poor in nutrients and organic matter. Although tofu wastewater has been recognized as a potential nutrient source, its effectiveness in improving Ultisol soil fertility has not been extensively studied. Therefore, based on the considerations above, this study was conducted to evaluate the effect of LOF derived from tofu factory wastewater on soil N, P, K availability and the C/N ratio in Ultisols.

2. Research Methods

2.1. Research Location

This research was conducted in a greenhouse, while laboratory analyses were carried out at the Soil Science Laboratory, Soil Science Study Program, Department of Soil Science, Faculty of Agriculture, Sriwijaya University, Ogan Ilir Regency, South Sumatra Province. The study was conducted from July to September 2022.

2.2. Methods

The study employed a Completely Randomized Design (CRD) consisting of six treatments with four replications, resulting in a total of 24 experimental units. The fertilizer treatments, which included tofu factory wastewater and NPK fertilizer, were as follows: (A) control; (B) single application of N, P, and K fertilizers according to the recommended dosage; (C) 125 ml of tofu factory wastewater combined with local microorganisms; (D) 250 ml of tofu factory wastewater combined with local microorganisms; (E) 375 ml of tofu factory wastewater combined with local microorganisms; and (F) 500 ml of tofu factory wastewater combined with local microorganisms.

2.3. Soil Media Preparation

Soil media preparation involved collecting Ultisol soil from a depth of 0–30 cm below the surface at the Experimental Garden of the Faculty of Agriculture, Sriwijaya University. The soil was air-dried for several days and then sieved using a 2 mm mesh. The prepared soil was placed into polybags measuring 40 cm × 50 cm, with each polybag containing 5 kg of soil, and then arranged in the greenhouse.

2.4 Application of LOF from Tofu Factory Wastewater

Liquid organic fertilizer derived from tofu factory wastewater was applied at planting time and subsequently applied once a week until one week before harvest. The LOF dosage was adjusted according to the respective treatments and diluted with water to a final volume of 200 ml prior to application. The diluted fertilizer was applied by pouring it evenly onto the soil surface in each polybag.

2.5. Observed variables

The variables analyzed in this study included total N, determined using the Kjeldahl method; available P, analyzed using the Bray I method; and exchangeable K, measured using 1 N NH_4OAc at pH 7. In addition, organic carbon C was determined using the Walkley and Black method, and the C/N ratio was calculated as the ratio of organic C to total N.

2.6. Data Analysis

The data obtained were analyzed using analysis of variance (ANOVA) at the 5% significance level. If the calculated F-value exceeded the F-table value at 5%, the treatment was considered to have a significant effect on the observed variables. Duncan's Multiple Range Test (DMRT) at the 5% level was then applied to determine differences among treatments.

3. Results and Discussion

3.1. Initial Soil and Analysis

The results of the initial soil analysis (Table 1) indicated that the soil used in this study had very low fertility. The soil pH was classified as very acidic, with a pH (H_2O) value of 3.96 and a pH (KCl) value of 3.68. The total N content of the Ultisol was 0.11%, which is categorized as very low. The available P content was 4.21 mg kg^{-1}, classified as low, while the available K content was 0.19 cmol kg^{-1}, also classified as low. In addition, the soil exhibited a high C/N ratio of 22.19. A high C/N ratio indicates that organic matter has not been fully decomposed, resulting in a higher proportion of carbon relative to nitrogen. This condition slows the decomposition process because microorganisms require nitrogen to effectively break down carbon.

Overall, the Ultisol used in this study was characterized by low fertility. One approach to improving the fertility of this soil is the application of ameliorants such as LOF. The use of LOF not only increases nutrient availability in the soil but also improves soil physical properties, including structure, porosity, and water-holding capacity. In addition, LOF enhances soil biological properties by serving as a source of energy and nutrients for soil microorganisms, thereby increasing microbial activity and population in the soil (Aryani et al., 2019).

Table 1. Initial soil analysis

Parameter	Unit	Analysis Results	Criteria *
Water content	%	36.15	
pH H_2O	-	3.96	Very sour
pH KCl	-	3.68	-
Organic C	%	2.44	Low
Total N	%	0.11	Very low
Available P	mg kg^{-1}	14.21	Low
Available K	cmol kg^{-1}	0.19	Low
C/N ratio	-	22.19	Tall

Note: *Criteria based on Soil Research Center (2009)

3.2. LOF Analysis

The results of the LOF analysis presented in Table 2 show that the pH of the LOF used in this study was 6.18. This pH value meets the standard requirements for organic fertilizer as specified in SNI 261/KPTS/SR.310/M/4/2019. The combined nutrient content of N, P, and K (2.92%) also fulfills the minimum nutrient content requirement for organic fertilizer, which is 2.00%. However, the relatively low individual contents of N, P, and K in the LOF derived from tofu factory wastewater mixed with banana stems are presumed to be due to the use of wastewater from the final stage of tofu production. At this stage, the wastewater contains lower levels of nitrogen and phosphorus because these nutrients are reduced during the treatment process. Nitrogen is removed through denitrification, while phosphorus is reduced through microbial coagulation processes. According to Lepongbulan et al. (2017), LOF contains a wide range of nutrients, but their concentrations are generally low and their effects are slower compared with those of inorganic fertilizers..

Table 2. Results of LOF analysis

Parameter	Unit	Mark	Criteria*
pH H_2O	-	6.18	Fulfil
Total N	%	0.83	-
Available P	%	0.03	-
Available K	%	2.06	-
N + P + K	%	2.92	Fulfil

Note: *Organic fertilizer standards (SNI: 261/KPTS /SR.310/M/4/2019)

Although the resulting values are relatively small, LOF still offers several advantages, including ease of application, improved nutrient absorption, no adverse effects on soil or plants, and increased nutrient availability (Suhastyo, 2019). In addition, liquid waste from the tofu industry contains various organic materials, including organic compounds that can be utilized as plant nutrients, such as 40–60% protein, 25–50% carbohydrates, 8–12% fat, and smaller amounts of calcium, phosphorus, and vitamins (Setiawan, 2022). Therefore, the nutrient content of tofu liquid waste makes it suitable for use as LOF.

3.3. The Effect of LOF on Soil Total N

Based on the results of the analysis of total N, the application of LOF at various doses had no significant effect on total N content. The mean values of total soil N under different LOF doses are presented in Table 3.

Table 3. The effect of LOF with stem decomposers against total N content of Ultisols

Treatment	Average Soil Total N (%)
A (Control)	0.14
B (Single fertilizer N, P and K)	0.15
C (LOF 125 ml)	0.12
D (LOF 250 ml)	0.17
E (LOF 375 ml)	0.17
F (LOF 500 ml)	0.19

Based on the analysis of total N, the application of LOF derived from tofu wastewater had no significant effect on total N content. However, treatments B, D, and F showed slight increases in total N compared with the control treatment, which had a value of 0.14% and was classified as low. As shown in Table 3, total N values among all treatments were relatively similar and generally fell within the low category. The low nitrogen content in the soil may be attributed to plant uptake, as reported by Patti et al. (2018) who stated that soil N availability influences plant N content and that N losses can occur due to several factors, including soil pH, temperature, and the type of clay minerals present.

Furthermore, Yuniarti et al. (2020) noted that increasing soil acidity negatively affects nitrogen availability. The soil pH in this study was classified as slightly acidic, which may have inhibited the nitrification process and consequently reduced nitrogen availability. This finding is also supported by Putra et al. (2015), who reported that nitrogen nutrients can be rapidly lost through volatilization, particularly when fertilizers are left exposed or applied under open conditions after fertilization.

3.4. The Effect of LOF on Soil Available P

Based on the results of the soil available P analysis, the application of LOF at various doses had no significant effect on soil available P. The mean values of soil available P under different LOF doses for pak choy cultivation are presented in Table 4.

Table 4. Effect of LOF with stem decomposers against soil available P content in Ultisols

Treatment	Average Soil Available P (mg kg^{-1})
A (Control)	23.23 a
B (Single fertilizer N, P and K)	49.18 b
C (LOF 125 ml)	20.10 a
D (LOF 250 ml)	22.19 a
E (LOF 375 ml)	21.90 a
F (LOF 500 ml)	24,26 a

Based on Table 4, the highest available phosphorus (P) content was observed in treatment (B), which received single N, P, and K inorganic fertilizers, with a value of 49.18 mg kg^{-1}. This result is attributed to the high phosphorus content of SP-36 fertilizer compared with that of LOF. As reported by Dahlia and Setiono (2020), SP-36 fertilizer contains a high level of phosphorus, approximately 36%. In most LOF treatments, except for treatment (F), the average soil available P values were lower than those of the control, which can be explained by the low phosphorus content in the LOF itself. In addition, the limited availability of phosphorus may be caused by plant uptake and by phosphorus fixation through binding with aluminum (Al) and iron (Fe), a process that commonly occurs in soils with acidic pH conditions (Yuniarti et al., 2020).

3.5. The Effect of LOF on Soil Available K

The results of the analysis showed that the application of LOF had a significant effect on soil available K. The values of soil available K are presented in Table 5.

Table 5. The effect of LOF with stem decomposers against soil available K content in Ultisols

Treatment	Average Soil Available K (cmol kg^{-1})
A (Control)	0.14 a
B (Single fertilizer N, P and K)	0.11 ab
C (LOF 125 ml)	0.45 b
D (LOF 250 ml)	1.04 c
E (LOF 375 ml)	0.96 c
F (LOF 500 ml)	1.60 d

Based on the results of the soil available K analysis, the highest available potassium content was observed in treatment (F) with a dose of 500 ml, which recorded an average value of 1.60 cmol kg^{-1}. This result indicates that the application of LOF at a dose of 500 ml had a significant effect on increasing soil available K compared with the control treatment, which had a value of only 0.14 cmol kg^{-1}. Other LOF treatments also showed increases in available K. The decomposition of organic matter releases K ions and enhances soil cation exchange capacity. Organic materials, such as plant and animal residues, contain nutrients including potassium, which are released into the soil solution in the form of K^+ ions during microbial decomposition, making them available to plants. This increase in potassium contributes to maintaining the balance of K levels in the soil. These findings are consistent with those of Afandi et al. (2015) who reported that the application of organic matter significantly increases soil available potassium.

In contrast, the lowest average available K value was found in treatment (B), which received only single N, P, and K inorganic fertilizers, with a value of 0.11 cmol kg^{-1}. This low value is likely influenced by acidic soil pH conditions as well as potassium uptake by plants. As stated by Sidhu et al. (2024) , potassium ions are classified as mobile elements, making them easily leached from the soil and readily absorbed by plants. In addition, potassium availability is strongly affected by soil pH; under acidic conditions, potassium is more easily lost from the soil (Putra, 2015).

3.6. The Effect of LOF on Soil C/N Ratio

The results show that the LOF treatment did not significantly affect the soil C/N ratio. The results of the soil C/N ratio analysis are presented in Table 6.

Table 6. The effect of LOF with stem decomposers against C/N ratio in Ultisols

Treatment	Average C/N Ratio
A (Control)	18.27
B (Single fertilizer N, P and K)	17.85
C (LOF 125 ml)	20.39
D (LOF 250 ml)	18.31
E (LOF 375 ml)	20.14
F (LOF 500 ml)	15.27

Based on Table 6, the highest C/N ratio in the treatment (C) LOF with a dose of 125 ml with an average value of 20.39. For the lowest value obtained in treatment (F) LOF dose with a dose of 500 ml which has a value of 15.27. The high or low C/N ratio affects the availability of nutrients, if the C/N ratio is high then the nutrient content is little available for plants (Sitompul et al., 2017) . This is in accordance with the results of the C/N ratio calculation that treatment (A) has a high C/N ratio value which indicates that the nutrients are relatively low because treatment A is a treatment without any fertilizer.

A low C/N ratio indicates high nutrient availability that can adequately meet plant growth requirements (Sitompul et al., 2017). This is consistent with the calculated C/N ratio in the LOF treatment at a dose of 500 ml, where the soil exhibited a low C/N ratio due to the higher nutrient content of the LOF compared with the control treatment (A).

A high C/N ratio indicates low nitrogen (N) content, whereas a low C/N ratio reflects a rapid decomposition process by bacteria that produces higher amounts of available N (Vrananta *et al.,* 2013) . This is consistent with treatments (C) and (E), which exhibited higher C/N ratio values than the control treatment (A) when viewed alongside the results of the N analysis (Table 3). Treatments (C) and (E) also showed the lowest soil N contents.

The C/N ratio plays a crucial role in soil nutrient availability. When the C/N ratio is high, abundant energy is available for soil microorganisms, allowing them to grow rapidly. Under these conditions, inorganic N compounds in the soil are quickly converted into organic N forms within microbial biomass, causing the rate of organic matter decomposition to reach its lowest level. The C/N ratio of organic matter added to the soil determines the reaction and rate of its decomposition; a high C/N ratio indicates that decomposition has not progressed or has only just begun (Rahmi and Biantary, 2014)

4. Conclusion

Based on the results of this study on the effect of LOF derived from tofu factory wastewater on nutrient availability in Ultisols, it can be concluded that the application of LOF had a very significant effect on available K, with a value of $P = 0.0002$ ($P < 0.005$). Among the treatments, the application rate of 500 ml was the most effective in increasing total N, available P, available K, and in producing the most favorable soil C/N ratio. Based on these findings, it is recommended to apply LOF from tofu liquid waste at a dose of 500 ml in combination with inorganic fertilizer to improve soil nutrient availability in Ultisols.

Acknowledgements

The authors would like to express their sincere gratitude to the Rector of Sriwijaya University for funding this research through the Sriwijaya University Public Service Agency (BLU) DIPA budget for the 2024 fiscal year, under Contract No. SP DIPA-023.17.2.677515/2022 dated December 13, 2021, in accordance with the Chancellor's Decree No. 0109/UN0.3.1/SK/2022 dated April 28, 2022.

References

Afandi, F.N., Siswanto, B., Nuraini, Y. 2015. Pengaruh pemberian berbagai jenis bahan organik terhadap sifat kimia tanah pada pertumbuhan dan produksi tanaman ubi jalar di Entisol Ngrangkah Pawon, Kediri. Jurnal

Tanah dan Sumberdaya Lahan 2(2), 237–244. https://jtsl.ub.ac.id/index.php/jtsl/article/view/134

Aryani, N., Hendarto, K., Wiharso, D., Niswati, A. 2019. Peningkatan produksi bawang merah dan beberapa sifat kimia tanah Ultisol akibat aplikasi vermikompos dan pupuk pelengkap. Journal of Tropical Upland Resources 1(1), 145-160. https://doi.org/10.23960/jtur.vol1no1.2019.18

Dahlia, I., Setiono. 2020. Pengaruh pemberian kombinasi dolomit + SP-36 dengan dosis yang berbeda terhadap pertumbuhan dan hasil tanaman kedelai (*Glycine max* L. *Merrill*) di Ultisol. Jurnal Sains Agro 5(1), 1–9. https://ojs.umb-bungo.ac.id/index.php/saingro/article/view/318

Gusnidar, G., Fitri, A., Yasin, S. 2019. Titonia and composted rice straw on soil chemical characteristics and corn production in Ultisols. Jurnal Solum 16(1), 11-18. https://doi.org/10.25077/jsolum.16.1.11-18.2019

Lepongbulan, W., Tiwow, V.M.A, Diah, A.W.M. 2017. Nutrient analysis of liquid organic fertilizer from Tilapia fish waste (*Oreochromis mosambicus*) of Lake Lindu with variations in the volume of local microorganisms (MOL) of banana stems. Jurnal Akademika Kimia 6(2), 92. https://doi.org/10.22487/j24775185.2017.v6.i2.9239

Marian, E., Tuhuteru, S. 2019. Pemanfaatan limbah cair tahu sebagai pupuk organik cair pada pertumbuhan dan hasil tanaman kubis cina. Agritrop 17(2), 134–144. https://doi.org/10.32528/agritrop.v17i2.2663

Patti, P.S, Kaya, E., Silahooy, C. 2018. Analisis status nitrogen tanah dalam kaitannya dengan serapan N oleh tanaman padi sawah di Desa Waimital, Kecamatan Kairatu, Kabupaten Seram Bagian Barat. Agrologia 2(1). https://doi.org/10.30598/a.v2i1.278

Pasang, Y.H, Jayadi, M., Neswati, R. 2019. Meningkatkan kandungan unsur hara fosfor pada tanah Ultisol melalui pemberian pupuk kandang, kompos, dan pelet. Ecosolum Journal 8(2), 86-96. https://doi.org/10.20956/ecosolum.v8i2.7872

Putra, A.D., Damanik, M., Hanum, H. 2015. Aplikasi pupuk urea dan pupuk kandang kambing untuk meningkatkan total nitrogen pada tanah Inceptisol Kwala Bekala dan hubungannya dengan pertumbuhan jagung (*Zea mays* L.). Jurnal Online Agroekoteknologi 3(1), 128–135.

Putra, B.W.R.I.H., Ratnawati, R. 2019. Pembuatan pupuk organik cair dari limbah buah dengan penambahan bioaktivator EM4. Jurnal Sains dan Teknologi Lingkungan 11(1), 44–56.

Putra, I. . 2015. Batas kritis kalium untuk tanaman jagung pada berbagai status nutrisi di tanah Inceiptisol. Agrica Extensia 9(1), 1–7.

Rahmi, A., Biantary, M.P. 2014. Karakteristik sifat kimia tanah dan status kesuburan tanah lahan halaman dan lahan pertanian di beberapa desa di Kabupaten Kutai Barat. Ziraa'ah 39(1), 30–36.

Rasmito, A., Hutomo, A., Hartono, A.P. 2019. Pembuatan pupuk organik cair dengan cara fermentasi limbah cair tahu, starter filtrat kulit pisang dan kubis, dan bioaktivator EM4. Jurnal IPTEK 23(1), 55–62. https://doi.org/10.31284/j.iptek.2019.v23i1.496

Setiawan, A., Siswanto, Y., Diki, M. 2022. Respons pertumbuhan bibit kakao (*Theobroma cacao* L.) akibat aplikasi pupuk organik cair dari limbah tahu dan kotoran ayam. Agriland: Journal of Agricultural Science 10(2), 144-150. https://jurnal.uisu.ac.id/index.php/agriland/article/view/5897

Sidhu, S.K., Zotarelli, L., Sharma, L.K. 2024. A review of potassium significance and management approaches in potato production under sandy soils. Journal of Sustainable Agricuture and Environment 3(2), e12106. https://doi.org/10.1002/sae2.12106

Sitompul, E., Wardhana, I. Wisnu, Sutrisno, E. 2017. Studi identifikasi rasio C/N pada pengolahan limbah organik sawi hijau, daun singkong, dan kotoran kambing dengan variasi komposisi menggunakan metode vermikompos. Jurnal Teknik Lingkungan 6(2), 1–12.

Suhastyo, A.A. 2019. pemberdayaan kelompok wanita tani melalui pelatihan pembuatan pupuk organik cair. Jurnal Penelitian dan Pengabdian Kepada Masyarakat UNSIQ 6(2), 60–64. https://doi.org/10.32699/ppkm.v6i2.580

Vrananta, S.D., Afiati, N., Soedarsono, P. 2013. Hubungan nisbah C/N dengan jumlah total bakteri pada sedimen tambak di areal balai besar pengembangan budidaya air payau, Jepara. Management of Aquatic Resources Journal (MAQUARES) 2(3), 265–272. https://doi.org/10.14710/marj.v2i3.4225

Widyabudinigsih, D., Troskilina, L., Fauziah, S. 2021. Pembuatan dan pengujian pupuk organik cair dari limbah kulit buah dengan penambahan bioaktivator EM4 dan variasi waktu fermentasi. IJCA (Indonesian Journal of Chemical Analysis) 4(1), 30–39. https://doi.org/10.20885/ijca.vol4.iss1.art4

Yuniarti, A., Solihin, E., Putri, A.T.A. 2020. Penerapan pupuk organik dan N, P, K pada pH tanah, P tersedia, penyerapan P, dan hasil panen padi hitam (*Oryza sativa* L.) pada tanah Inceptisol. Jurnal Kultivasi 19(1), 1040-1046. https://doi.org/10.24198/kultivasi.v19i1.24563