JOURNAL OF DEGRADED AND MINING LANDS MANAGEMENT
Volume 10, Number 3 (April 2023):4527-4535, doi:10.15243/jdmlm.2023.103.4527
ISSN: 2339-076X (p); 2502-2458 (e), www.jdmlm.ub.ac.id

Research Article

Application of cow manure and *Gliricidia sepium* pruning compost to improve physical properties of Ultisols and soybean yield

Zurhalena, Endriani, Yulfita Farni, Najla Anwar Fuadi*

Agroecotechnology Department, Agriculture Faculty, Universitas Jambi, Kampus Pinang Masak, Mendalo Indah, Jambi 36361, Indonesia

*corresponding author: najlaaf@unja.ac.id

Article history:
Received 26 November 2022
Accepted 21 January 2023
Published 1 April 2023

Keywords:
compost
cow manure
Gliricidia pruning
soybean
Ultisols

Abstract

Ultisols have considerable potential in developing agricultural cultivation, but in their management, they face several obstacles, including physical properties that do not adequately support plant growth. The low content of soil organic matter causes poor soil physical properties. Low organic matter content leads to low soil aggregate stability, obstructing pore distribution and infiltration so the soil can easily become compacted. This study aimed to observe the changes in some physical properties of the soil due to the application of cow manure and *Gliricidia sepium* pruning compost and its effect on the yield of soybean plants. This study used a randomized block design with five treatments, namely, K0 (without cow manure-Gliricidia compost), K1 (5 t ha^{-1} cow manure-Gliricidia compost), K2 (10 t ha^{-1} cow manure-Gliricidia compost), K3 (15 t ha^{-1} cow manure-Gliricidia compost), and K4 (20 t ha^{-1} cow manure-Gliricidia compost). The results showed that the 15 t ha^{-1} cow manure-Gliricidia compost was the best dose in improving the total pore space and penetration resistance of the soil studied. The application of 15 t ha^{-1} cow manure-Gliricidia compost significantly increased soybean yield, reaching 2.97 t ha^{-1}.

To cite this article: Zurhalena, Endriani, Farni, Y. and Fuadi, N.A. 2023. Application of cow manure and *Gliricidia sepium* pruning compost to improve physical properties of Ultisols and soybean yield. Journal of Degraded and Mining Lands Management 10(3):4527-4535, doi:10.15243/jdmlm.2023.103.4527.

Introduction

Ultisols are soils with the broadest distribution in Indonesia, around 45.8 million hectares or about 25% of the land area of Indonesia (Syahputra et al., 2015). In Jambi Province, the area of Ultisols reaches 2.27 million hectares or 42.53% of the area of Jambi Province (BPN Jambi Province, 2010). Ultisols can be used for cultivating soybean to meet the increasing demand for soybeans. However, the soybean yield on Ultisols in Jambi is still very low. This is because of the physical properties of Ultisol that interfere with the growth of soybean plants.

Ultisols have low porosity, infiltration rate, permeability, aggregate stability, water-holding capacity, and organic matter content (Yulnafatmawita et al., 2013; Murniati et al., 2022). These characteristics make Ultisols very susceptible to degradation (Muukkonen et al., 2009), increase surface runoff and soil erosion (Girmay et al., 2009) and cause a reduction in planted area (Gyssels and Poesen, 2003; Marques et al., 2007; Martinez et al., 2008). Poor soil physical properties can interfere with the development of plant roots because it is difficult for roots to penetrate the soil, making it difficult for roots to absorb nutrients (Zhang and Fang, 2007; Haridjaja et al., 2010; Kakabouki et al., 2021). Therefore, efforts to improve soybean growth and yield in Ultisols should begin with the improvement of soil physical properties, such as aggregate stability, bulk density, and soil pore space.

Soil organic matter is important in maintaining soil structural stability, aiding air and water infiltration, increasing water retention and reducing erosion (Li et al., 2007). The organic matter directly influences plant growth and yield by providing nutrients or indirectly by modifying soil physical properties such as aggregate stability, porosity and available water capacity, which can improve the root environment and stimulate plant growth (Angst et al., 2017). The reduction of soil available water capacity is considered the main factor of loss of soil productivity due to erosion. This reduction in the available water capacity of the soil is associated with changes caused by the water-retaining characteristics of the root zone or by a reduction in the depth of the root zone (Yu et al., 2007).

One source of organic material widely available on land dominated by Ultisols in Jambi is the pruning of *Gliridia sepium* plant (locally known as Gamal). Some researchers reported that Gliricidia pruning contains 3.15% N, 1.35% Ca and 0.22% P (Jayadi, 2009; Paulus et al., 2018). However, the community has not widely used the potential of Gliricidia pruning as a source of organic matter to improve the properties of Ultisols (Safria et al., 2017). Gliricidia pruning can be applied to the soil in fresh form or compost. Composted organic matter can provide micro-nutrients for plants, loosen soil, improve soil structure, increase porosity, improve soil aeration, increase water holding capacity of the soil and facilitate root growth (Paramananthan, 2013). In addition, applying organic matter in the form of compost can increase aggregate stability, reduce soil bulk density, and enlarge soil pores during harvest (Widodo and Kusuma, 2018; Ningsih et al., 2022).

Another source of organic matter that can easily be found in areas dominated by Ultisols in Jambi is cow dung manure. Adekiya et al. (2016) reported that applying cow dung manure from 0-10 t ha^{-1} improved soil physical properties and maize yield. The application of 10 t ha^{-1} cow manure increased the dry grain weight of maize by 115, 79, 75, 65 and 49% compared to 0, 2, 4, 6 and 8 t ha^{-1} of cow dung manure. The addition of cow dung manure resulted in a significant increase in soil organic carbon, macro-aggregate stability and aggregate-protected carbon in clay soils (Dunjana et al., 2012). Nyamagara et al. (2021) reported that the application of cow dung manure increased soil organic carbon by 10-38% in a layer of 0-10 cm, increased soil aggregate stability and aggregate index, and soil available water capacity.

The incorporation of organic matter, either in the form of crop residues (leaves) or manure, has been shown to improve soil structure and water retention capacity (Rasoulzadeh and Yaghoubi, 2010) and soil chemical properties. Farni et al. (2022) reported that applying Tithonia and sugarcane leaves affected soil pH and exchangeable soil bases, increasing nutrient uptake by maize plants. Singh et al. (2007) reported that green manure, manure and crop residues improved soil structure. A historical review of the effects of organic matter on soil physical properties has been reported by other researchers (Celik et al., 2004; Celik, 2005; Hati et al., 2006; Masri and Ryan, 2006).

This study aimed to ascertain the effect of cow manure and Gliricidia pruning compost on some physical characteristics of Ultisols and soybean yield.

Materials and Methods

A field experiment was carried out in Tangkit Lama Village, Sungai Gelam District, Muaro Jambi Regency, Jambi Province, from March to July 2020. The soil in the experimental site belongs to the Ultisol order with the following physical characteristics: organic matter content = 3.15%, bulk density = 1.45 g cm^{-3}, total pore space = 47.90%, aggregate formed = 55.42%, and aggregate stability = 48% (unstable), 40% (high), 10.3% (low).

The materials used in this study were prunings (young stems and leaves) of *Gliricidia sepium* (local name "Gamal") and cow manure obtained from the area nearby the experimental site in Tangkit Lama Village, Sungai Gelam District, Muaro Jambi Regency, Jambi Province. Dried Gliricidia pruning and dried cow manure were mixed in a ratio of 3:1 (3 parts cow manure and 1 part Gliricidia pruning). The mixture was then fermented for one month by adding Trichoderma and phosphate until the mixture turned to compost (hereafter called cow manure-Gliricidia compost).

The treatments tested were the doses of cow manure-Gliricidia compost, namely K0 (without cow manure-Gliricidia compost), K1 (5 t ha^{-1} cow manure-Gliricidia compost), K2 (10 t ha^{-1} cow manure-Gliricidia compost), K3 (15 t ha^{-1} cow manure-Gliricidia compost), and K4 (20 t ha^{-1} cow manure compost-Gliricidia compost). Each mixture was incorporated in a respected plot in the field measuring 3 m x 2 m with a distance between blocks of 1 m. A week after the application of cow manure-Gliricidia compost, the plots were then planted with soybeans with a spacing of 50 cm x 20 cm. The basal fertilizers given were 50 kg ha^{-1} Urea (as N fertilizer), 100 kg ha^{-1} TSP (as P fertilizer), and 100 kg ha^{-1} KCl (as K fertilizer). The five treatments were arranged in a randomized block design with five replications. During the plant growth, watering, weeding and pest control were carried out regularly to keep the plants growing well.

Harvesting was conducted when the plants reached 84 days old after planting. At harvest time, soil samples were taken from each treatment plot for analysis of soil organic matter content, soil bulk density, total pore space, soil aggregates and soil penetration resistance. The organic C content was determined by the furnace method, the bulk density was measured by the gravimetric method, and the soil penetration resistance was measured by using a cone penetrometer at a depth of 10 cm, 20 cm, and 30 cm. The soil analysis was carried out at the Laboratory of

Soil Science, Faculty of Agriculture, Universitas Jambi. The plant parameters observed at harvest were plant height and yield.

The data obtained were subjected to the analysis of variance (ANOVA) at the 95% confidence level ($\alpha = 5\%$), followed by the Duncan Multiple Range Test (DMRT) to detect differences between treatments.

Results and Discussion

Soil organic matter content, aggregate formed and aggregate stability

The application of cow manure-Gliricidia compost significantly improved the physical and chemical characteristics of the Ultisol studied (Table 1). The increase of organic matter was significantly different when cow manure-Gliricidia compost was applied at doses of 5 t ha^{-1} to 20 t ha^{-1} compared to the control, but there was no difference between compost treatments at doses of 5 t ha^{-1}, 10 t ha^{-1}, 15 t ha^{-1}, or 20 t ha^{-1}. The organic matter content of the soil was able to rise by 4.70% (without treatment) to 7.78% after the application of cow manure-Gliricidia compost. The amount of organic matter increased from a low category before treatment to a medium category after treatment when cow manure-Gliricidia compost was applied at a dose of 5 t ha^{-1} to 20 t ha^{-1}. Olubukola et al. (2010), Soelaeman and Haryati (2012), and Lerch et al. (2019) pointed out that compost made from animal manure is crucial for improving soil fertility, soil physics, and soil biology. Compost can be used to increase soil organic matter, and the more compost that is used, the higher the soil organic matter concentration will be. According to Subowo (2010), soils with organic matter levels over 2% significantly benefit plants because the organic matter may hold onto moisture, raise pH, prevent the formation of hard soil structures, increase cation exchange capacity, and boost soil fertility and biological activity.

Table 1. The effect of cow manure-Gliricidia compost on soil organic matter content, percentage of aggregate formed, and aggregate stability.

Treatment	Organic Matter (%)	Aggregate Formed (%)	Aggregate Stability (%)
K0 (control)	4.70 a	56.45 a	47.20 a
K1 (5 t ha^{-1} cow manure-Gliricidia compost)	6.84 b	67.19 b	52.82 b
K2 (10 t ha^{-1} cow manure-Gliricidia compost)	7.01 b	69.15 b	54.45 b
K3 (15 t ha^{-1} cow manure-Gliricidia compost)	7.70 b	73.82 b	55.38 b
K4 (20 t ha^{-1} cow manure-Gliricidia compost)	7.08 b	70.00 b	55.02 b

Notes: Numbers followed by the same letter in the same column are not significantly different according to DMRT at the level of 5%.

Table 1 shows that the application of cow manure-Gliricidia compost at doses of 5, 10, 15 and 20 t ha^{-1} was able to increase the percentage of aggregate formed and aggregate stability when compared with no treatment with cow manure-Gliricidia compost. This means that the addition of cow manure-Gliricidia compost to the soil can increase the amount of organic matter, which can improve the aggregate formation

The application of cow manure-Gliricidia compost at a dose of 5 t ha^{-1} to 20 t ha^{-1} increased the percentage of aggregate formed compared to no treatment. This is because the cow manure-Gliricidia compost will undergo a decomposition process to produce organic acids that function as adhesives that can increase the process of aggregate formation and stabilize soil aggregates. Giving cow manure-Gliricidia compost at a dose of 5 t ha^{-1} has increased the activity of microorganisms so that the decomposition process of organic matter takes place quickly and produces humus. According to Zulkarnain et al. (2013), humus has a functional group that is negatively charged and can bind to positively charged soil particles to form soil aggregates. The results showed that the application of cow manure-Gliricidia compost significantly affected the aggregate stability (Table 1). The application of cow manure-Gliricidia compost from 5 t ha^{-1} to 20 t ha^{-1} increased the stability of aggregates compared to no treatment. Soil aggregate stability rose from 47.20% (without treatment) to 55.37% (15 t ha^{-1} cow manure-Gliricidia compost). This is because cow manure-Gliricidia compost, during the decomposition process, can contribute organic acids that can function as adhesives between soil particles so that they will form a more stable aggregate. The application of compost at a dose of 5 t ha^{-1} to 20 t ha^{-1} did not show a significant difference, so it can be said that a dose of 5 t ha^{-1} could increase the stability of soil aggregates. This is because a dose of 5 t ha^{-1} cow manure-Gliricidia compost can contribute more organic matter to the soil; with increasing organic matter content in the soil, the stability of soil aggregates will also increase. According to Dariah et al. (2015), organic matter such as manure functions as a natural soil enhancer and acts as a stabilizer for micro, meso, and macro aggregates of the soil.

Soil bulk density and total pore space

The bulk density values of the soils treated with 10, 15, and 20 t ha^{-1} cow of manure-Gliricidia compost differed considerably from those without cow manure-Gliricidia compost (Table 2). The bulk density of the soils treated with cow manure-Gliricidia compost drastically reduced compared to the soil without adding cow manure-Gliricidia compost. The lowest soil bulk density value was obtained by applying cow manure-Gliricidia compost at a dose of 15 t ha^{-1}, which was also not substantially different from the bulk density value obtained at a dose of 20 t ha^{-1}. This shows that cow manure-Gliricidia compost at a dose of 15 t ha^{-1} is the best dose to reduce soil bulk density, which reduced it by 14% compared to that of the soil without cow manure-Gliricidia compost. This is presumably because the cow manure-Gliricidia compost applied to the soil underwent decomposition that produced organic acids. Organic acids have the ability to bind soil grains. Soil grains that bind to each other form the soil structure, and then the soil becomes less and more soil pores are formed, so the bulk density of the soil will decrease.

Table 2. The effect of cow manure-Gliricidia compost on soil volume and total pore space.

Treatment	Bulk Density (g cm^{-3})	Total Pore Space (%)
K0 (control)	1.50 a	42.09 a
K1 (5 t ha^{-1} cow manure-Gliricidia compost)	1.45 ab	43.77 ab
K2 (10 t ha^{-1} cow manure-Gliricidia compost)	1.40 b	46.21 b
K3 (15 t ha^{-1} cow manure-Gliricidia compost)	1.24 c	52.12 c
K4 (20 t ha^{-1} cow manure-Gliricidia compost)	1.28 c	51.11 c

Note: The numbers followed by the same letter in the same column are not significantly different according to DMRT at the level of 5%.

Widodo and Kusuma (2018) reported that compost could increase aggregate stability, reduce soil density, and increase soil pores at harvest. In this study, the percentages of total pore space of the soil treated with cow manure-Gliricidia compost at doses of 10, 15, and 20 t ha^{-1} were significantly different from that of the soil without cow manure-Gliricidia compost. The highest total pore space was in the treatment of cow manure-Gliricidia compost with a dose of 15 t ha^{-1} but showed no significant difference with the treatment of 20 t ha^{-1}. Cow manure-Gliricidia compost might help microorganisms in the soil to break down the organic in the soil to produce organic acids that can bind soil particles. Then soil aggregates will be formed; the soil pores will increase so that the total value of the soil pore space increases. The total pore space is also related to the soil bulk density; if the soil bulk density decreases, the total pore space of the soil will increase. Results of this study showed that the bulk density of the soil might be decreased by applying 10, 15, and 20 t ha^{-1} cow manure-Gliricidia compost. This study revealed that 10 t ha^{-1} cow manure-Gliricidia compost significantly reduced the soil total pore space. According to Surya et al. (2017), organic matter will make the soil more friable and improve soil aeration and structure, soil bulk density, and total soil porosity, further enhancing nutrient availability. The application of cow manure-Gliricidia compost increased the soil porosity. Meng et al. (2005) and Kakabouki et al. (2021) reported that the mixture of cow manure-Gliricidia compost has the best effect on total soil porosity.

Penetration resistance and soil moisture content

According to Table 3, there were no appreciable variations in the penetration resistance of the soil at a depth of 10 cm after receiving cow manure-Gliricidia compost. When cow manure-Gliricidia compost was added, the soil penetration resistance at a depth of 20 cm was considerably different from the control. This demonstrates how compost made from Gliricidia pruning and cow manure can considerably lessen soil resistance to penetration. Organic matter enhances the soil's crumb structure. Low penetration resistance results from crumbly soil. The soil bulk density and penetration resistance are two further indicators. If the soil bulk density is high, the penetration resistance is also high, and vice versa. The results presented in Table 3 show that the soil bulk density value in the treatment of 15 t ha^{-1} cow manure-Gliricidia compost was the lowest (1.29 g cm^{-3}), so the penetration resistance of the treatment of 15 t ha^{-1} cow manure-Gliricidia compost also showed the lowest penetration resistance (22.66 bar).

Penetration resistance is also related to the total pore space of the soil, where when the total pore space of the soil is increased or high, the penetration resistance decreases. The total pore space of the soil in the treatment of 15 t ha^{-1} cow manure-Gliricidia compost significantly reduced the value of soil bulk density. Soil that has many pores and low bulk density causes the penetration resistance to decrease. Endriani (2010), Rigane and Medhioub (2011) and Kakabouki et al. (2021), in their research showed that the higher the organic matter content, the lower the soil density, so penetration resistance is reduced and the application of organic fertilizers and natural waste has a beneficial effect on the quality of soil structure, macropores, thereby reducing penetration resistance. Penetration resistance at a depth of 30 cm of the soil that was given cow manure-Gliricidia compost at doses of 5 t ha^{-1} and 10 t ha^{-1} did not show any significant difference compared to the control. It is suspected that at a depth of 30 cm, the influence of clay content is stronger than the organic matter. Clay has a very strong inter-particle binding capacity which causes the soil pores to narrow so that the penetration resistance is high and the bulk density also increases. Figures 1, 2 and 3 show fluctuations in the penetration resistance at each depth of 10, 20, and 30 cm, showing the fluctuation of soil penetration resistance. Fluctuations in soil penetration at the study site are more influenced by rainfall, affecting soil water content. High rainfall causes the penetration resistance to decrease because the water content in the soil is quite large, which makes the soil soft. According to Nafisah et al. (2016), penetration resistance in the soil is influenced by soil moisture content, texture, bulk density, and organic matter content. Jeyaseeli et al. (2021) and Punitha et al. (2021) indicated low soil thermal conductivity results in good crop productivity and increased soil water holding capacity.

Table 3. The effect of cow manure-Gliricidia compost on penetration resistance and soil water content.

Treatment	Penetration Resistance (Bar)			Water Content (%)
	10 cm depth	20 cm depth	30 cm depth	
K0 (control)	14.28 a	25.80 a	35.38 a	10.92 a
K1 (5 t ha^{-1} cow manure-Gliricidia compost)	13.74 a	23.62 b	33.48 ab	16.68 b
K2 (10 t ha^{-1} cow manure-Gliricidia compost)	13.74 a	23.48 b	33.82 ab	16.90 b
K3 (15 t ha^{-1} cow manure-Gliricidia compost)	12.96 a	22.66 b	31.94 b	17.00 b
K4 (20 t ha^{-1} cow manure-Gliricidia compost)	13.14 a	22.74 b	31.92 b	17.57 b

Note: The numbers followed by the same letter in the same column are not significantly different according to DMRT at the level of 5%.

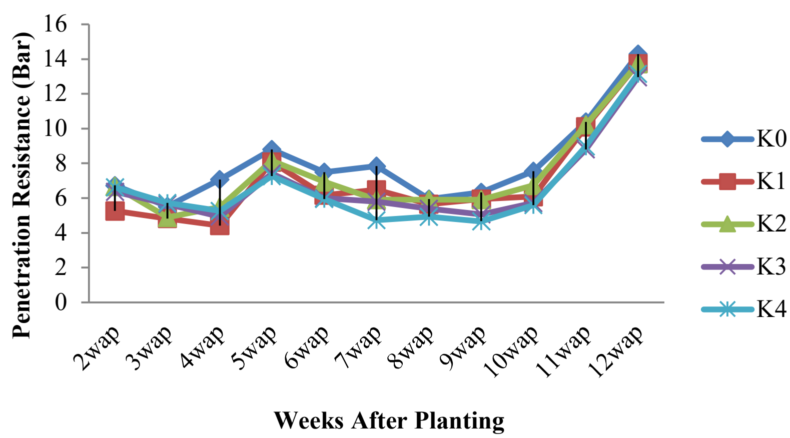

Figure 1. Fluctuation of 10 cm depth penetration resistance.

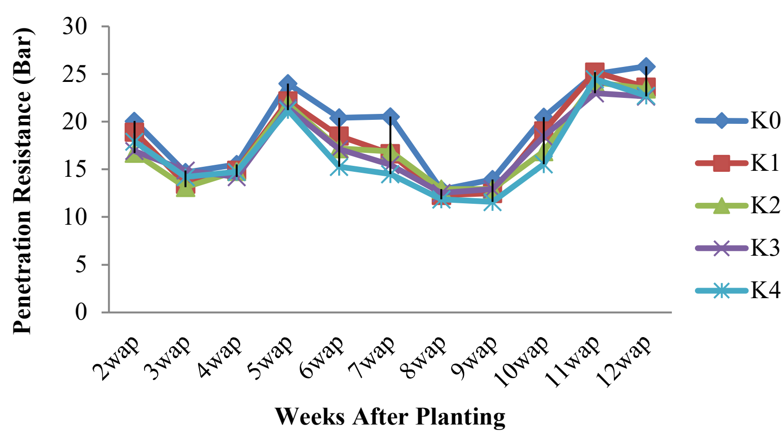

Figure 2. Fluctuation of 20 cm depth penetration resistance.

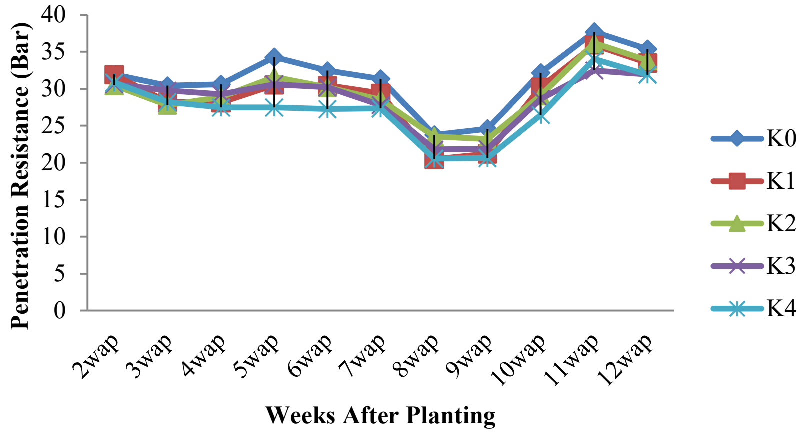

Figure 3. Fluctuation of 30 cm depth penetration resistance.

Figure 4 shows soil moisture content from two weeks after planting to 12 weeks after planting. Overall, every weekly observation of soil moisture content that was not composted with cow manure and Gliricidia pruning had the lowest water content. The soil on land that is not composted with cow manure and Gliricidia pruning does not have sufficient ability to hold water because it has low organic matter. One of the abilities of organic matter is to bind water in the soil. According to Intara et al. (2011), Pane et al. (2011), and Kakabouki et al. (2021), the ability of soil to hold water is influenced by soil texture and organic matter.

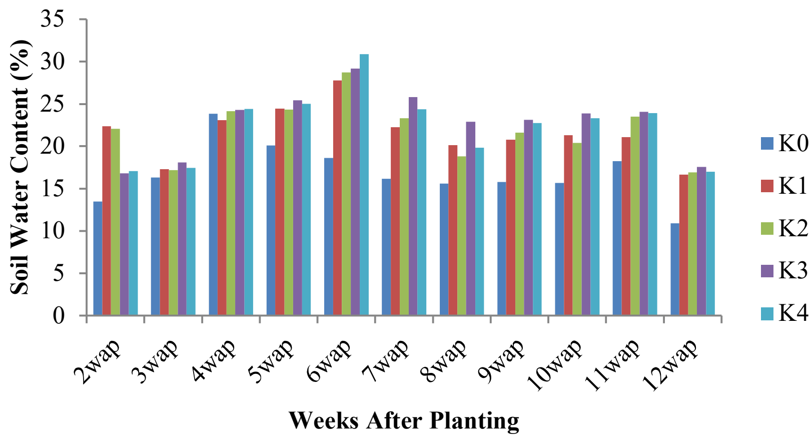

Figure 4. Soil water content.

Table 3 shows that the application of cow manure-Gliricidia compost significantly affects soil moisture content. Cow manure-Gliricidia compost can maintain the water content in the soil. Soil moisture content is maintained due to the influence of compost that is applied to the soil. Compost that has been decomposed will produce humus. Humus can hold water four to six times its weight. Celik et al. (2004) revealed that the application of compost and manure increased the available water content by 56% and 86% in each treatment. According to Intara et al. (2011), the humus is hydrophilic; therefore, humus can increase the absorption of water in the soil and also causes high water retention. According to Memon et al. (2018), Jat et al. (2019), and Jahangir et al. (2021), the use of organic amendments, crop residues and organic fertilizers is better for the soil than the use of single chemical fertilizers.

Plant height and soybean yield

Table 4 demonstrates that there was no significant difference between treatments for plant height when cow manure-Gliricidia compost was applied at doses of 5 t ha^{-1} to 20 t ha^{-1}, but on soybean yields, it was observed that the application of cow manure-Gliricidia compost at a dose of 15 t ha^{-1} had already demonstrated a significant difference in comparison to the control. Because of the improvements in soil physical properties brought about by the application of compost, such as improvements in bulk density, total pore space for aggregate formation and stability, as well as improvements in soil penetration resistance, there was a significant difference in soybean yields between the treatments using cow manure-Gliricidia compost of 15 t ha^{-1}. The organic matter available in the soil can create a good growing medium for plant roots by improving the physical properties of the soil. In addition, the results of weathering organic matter will also provide the nutrients needed for growth to improve plant growth and yields.

Table 4. The effect of cow manure-Gliricidia compost on soybean growth and yield.

Treatment	Plant Height (cm)	Crop Yield (t ha^{-1})
K0 (control)	89.85 a	2.43 a
K1 (5 t ha^{-1} cow manure-Gliricidia compost)	90.13 a	2.60 ab
K2 (10 t ha^{-1} cow manure-Gliricidia compost)	92.37 a	2.80 ab
K3 (15 t ha^{-1} cow manure-Gliricidia compost)	93.34 a	2.97 b
K4 (20 t ha^{-1} cow manure-Gliricidia compost)	90.36 a	2.87 b

Notes: Numbers followed by the same letter in the same column the same is not significantly different according to DMRT at the level of 5%.

This is in line with the report of Teka (2013) that manure can provide nutrients and improve soil fertility needed for plant growth. The use of cow manure can stimulate overall plant growth due to the presence of nitrogen, phosphorus, and potassium elements in cow manure. Cambardella et al. (2003), Widodo and Kusuma (2018), and Lerch et al. (2019) suggested that the primary source of soil nitrogen is cow manure or organic matter, which also has a considerable impact on the environment and the physical, chemical, and biological characteristics of the soil. Farmers in the area frequently use organic fertilizers to boost the fertility of their arable soils and increase crop yield (Peng et al., 2016; Lin et al., 2018; Kakabouki et al., 2021).

Compost is helpful as a direct source of plant food and has the power to improve soil water retention and boost plant growth. Compost may be a significant source of nutrients for plants and has been found to have a variety of positive effects on soil quality. Although many completed composts have these advantages documented, it is still unknown how the circumstances of the composting process and the degree of compost decomposition affect soil C and N mineralization following compost insertion (Cambardella et al., 2003; Lerch et al., 2019).

Conclusion

The mixture of cow manure and *Gliricia sepium* pruning can be used to improve the physical properties of Ultisols of Jambi. The application of 15 t ha^{-1} cow manure-Gliricidia compost reduced bulk density and increased pore space, penetration resistance, and aggregate stability of Ultisols of Jambi. The application of 15 t ha^{-1} cow manure-Gliricidia compost also increased the yield of soybean grown on the soils by 2.97 t ha^{-1}.

Acknowledgements

The authors acknowledge the Faculty of Agriculture Universitas Jambi for supporting this research.

References

Adekiya, A.O., Ojeniyi. S.O. and Owonifari, O.E. 2016. Effect of cow dung on soil physical properties, growth and yield of maize (*Zea mays*) in a tropical Alfisol. *Scientia Agriculturae* 15(2):374-379, doi:10.15192/PSCP.SA.2016.15.2.374379.

Angst, G., Mueller, K.E., Kögel-Knabner, I., Freeman, K.H. and Mueller, C.W. 2017. Aggregation controls the stability of lignin and lipids in clay-sized particulate and mineral associated organic matter. *Biogeochemistry* 132:307-324, doi:10.1007/s10533-017-0304-2.

BPN Jambi Province. 2010. Area and Soil Type of Jambi Province (*in Indonesian*).

Cambardella, C.A., Richard, T.L. and Russel, A. 2003. Compost mineralization in soil as a function of composting process conditions. *European Journal of Soil Biology* 39(3):117-127, doi:10.1016/S1164-5563(03)00027-X.

Celik, I. 2005. Land-use effects on organic matter and physical properties of soil in a southern Mediterranean highland of Turkey. *Soil and Tillage Research* 83:270-277, doi:10.1016/j.still.2004.08.001.

Celik, I., Ortas, I. and Kilic, S. 2004. Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a chromoxerert soil. *Soil and Tillage Research* 78:59-67, doi:10.1016/j.still.2004.02.012.

Dariah, A., Sutono, S., Nurida, N.L., Hartatik, and Pertiwi, E. 2015. Soil amendments to increase agricultural land productivity. *Jurnal Sumberdaya Lahan* 9:67-84, doi:10.21082/jsdl.v9n2.2015.%25p (*in Indonesian*).

Dunjana, N., Nyamugafata, P., Shumba, A., Nyamangara, J. and Zingore, S. 2012. Effects of cattle manure on selected soil physical properties of smallholder farms on two soils of Murewa. Zimbabwe. *Soil Use and Management* 28(2):221-228, doi:10.1111/j.1475-2743.2012.00394.x.

Endriani. 2010. Physical properties and soil water content due to the application of conservation tillage. *Jurnal Hirdolitan* 1:26-34 (*in Indonesian*).

Farni, Y., Suntari, R. and Prijono, S. 2022. Utilization of *Tithonia diversifolia* and sugarcane leaves to improve soil properties and plant growth on a degraded sandy soil of Malang, East Java. *Journal of Degraded and Mining Lands Management* 9(2):3227-3236, doi:10.15243/jdmlm.2022.092.3227.

Girmay, G., Singh, B.R., Nyssen, J. and Borrosen, T. 2009. Runoff and sediment-associated nutrient losses under different land uses in Tigray. Northern Ethiopia. *Journal of Hydrology* 376:70-80, doi:10.1016/j.jhydrol.2009.07.066.

Gyssels, G. and Poesen, J. 2003. The importance of plant root characteristics in controlling concentrated flow erosion rates. *Earth Surface Processes and Landforms* 28(4):371-384, doi:10.1002/esp.447.

Haridjaja, O., Hidayat, Y. and Maryamah, L.S. 2010. The effect of soil bulk density on soil physical properties and germination of peanut and soybean seeds. *Jurnal Ilmu Pertanian Indonesia* 15:147-152 (*in Indonesian*).

Hati, K.M., Mandal, K.G., Misra, A.K., Ghosh, P.K. and Bandyopadhyay, K.K. 2006. Effect of inorganic fertilizer and farmyard manure on soil physical properties, root distribution and water-use efficiency of soybean in Vertisols of central India. *Bioresource Technology* 97:2182-2188, doi:10.1016/j.biortech.2005.09.033.

Intara, Y.I., Sapei, A., Erizal, E., Sembiring, N. and Djoefrie, M.H.B. 2011. The effect of adding organic matter to clay and clayey clay on the ability to bind water. *Jurnal Ilmu Pertanian Indonesia* 16:130-135 (*in Indonesian*).

Jahangir, M.M.R., Islam, S., Nitu, T.T., Uddin, U., Kabir, A.K.M.A., Meah, M.B. and Islam, R. 2021. Biocompost based integrated soil fertility management improves post harvest soil structural and elemental quality in a two year conservation agricultural practice. *Journal of Agronomy* 11(11):1-17, doi:10.3390/agronomy11112101.

Jat, H.S., Datta, A., Choudhary, M., Yadav, A.K., Choudhary, V., Sharma, P.C., Gathala, M.K., Jat, M.L. and McDonald, A. 2019. Effects of tillage. crop establishment and diversification on soil organic carbon, aggregation, aggregate associated carbon and productivity in cereal systems of semi-arid Northwest India. *Soil and Tillage Research* 190:128-138, doi:10.1016/j.still.2019.03.005.

Jayadi, M. 2009. The effect of gamal leaves liquid organic fertilizer and inorganic fertilizer on the growth of corn plants. *Jurnal Agrisistem* 5(2):115-122 (*in Indonesian*).

Jeyaseeli, P., Jeyamangalam, F., Selvaraj, S. and Durai, S.C.V. 2021. Conductivity and particle size measurement in sandy loam soil using organic amendment. *Rasayan Journal of Chemistry* 14:74-81, doi:10.31788/RJC.2021.1416119.

Kakabouki, I., Folina, A., Efthimiadou, A., Karyadogianni, S., Zisi, C., Kouneli, V., Kapsalis, N.C., Katsenios, N. and Travos, I. 2021. Evaluation of processing tomato pomace after composting on soil properties, yield and quality of processing tomatoes in Greece. *Agronomy* 11(88):1-15, doi:10.3390/agronomy11010088.

Lerch, T.Z., Dignac, M.F., Thevenot, M., Mchergui, C. and Houot, S. 2019. Chemical changes during composting of plant residues reduce their mineralization in soil and cancel the priming effect. *Soil Biology and Biochemistry* 136, September 2019:107525, doi:10.1016/j.soilbio.2019.107525.

Li, X., Li, F., Zed. R., Zhan, Z. and Singh, B. 2007. Soil physical properties and their relations to organic carbon pools as affected by land use in an alpine pastureland. *Geoderma* 139:98-105, doi:10.1016/j.geoderma.2007.01.006.

Lin, Y., Ye, G., Liu, D., Ledgard, S., Luo, J., Yuan, J., Chen, Z. and Ding, W. 2018. Long-term application of lime or pig manure rather than plant residues suppressed diazotroph abundance and diversity and altered community structure in an acidic Ultisol. *Soil Biology and Biochemistry* 123:218-228, doi:10.1016/j.soilbio.2018.05.018.

Marques, M.J., Bienes, R., Jiménez, L. and Pérez-Rodríguez, R. 2007. Effect of vegetal cover on runoff and soil erosion under light intensity events. Rainfall simulation over USLE plots. *Science of The Total Environment* 378:61-65, doi:10.1016/j.scitotenv.2007.01.043.

Martínez, L., López, A.J. and Bellinfante, N. 2008. Seasonal variability of runoff and soil loss on forest road backslopes under simulated rainfall. *Catena* 74(1):73-79, doi:10.1016/j.catena.2008.03.006.

Masri, Z. and Ryan, J. 2006. Soil organic matter and related physical properties in a Mediterranean wheat-based rotation trial. *Soil and Tillage Research* 87:146-154, doi:10.1016/j.still.2005.03.003.

Memon, M.S., Guo, J., Tagar, A.A., Perveen, N., Ji, C., Memon, S.A. and Memon, N. 2018. The effects of tillage and straw incorporation on soil organic carbon status. rice crop productivity. and sustainability in the rice-wheat cropping system of Eastern China. *Sustainability* 2018 10(4):961, doi:10.3390/su10040961.

Meng, L., Ding, W.X. and Cai, Z.C. 2005. Long-term application of organic manure and nitrogen fertilizer on N_2O emissions. soil quality and crop production in a sandy loam soil. *Soil Biology and Biochemistry* 37:2037-2045, doi:10.1016/j.soilbio.2005.03.007.

Murniati, A., Dini, I.R. and Razeka, M. 2022. Utilization of biochar and NPK fertilizer for soybean planting in Ultisol media. *International Journal of Science and Research Archive* 7:283-291, doi:10.30574/ijsra.2022.7.1.0198.

Muukkonen, P., Hartikainen, H. and Alakukku, L. 2009. Effect of soil structure disturbance on erosion and phosphorus losses from Finnish clay soil. *Soil and Tillage Research* 103:84-91, doi:10.1016/j.still.2008.09.007.

Nafisah, F., Purwakusuma, W. and Baskoro, D.P.T. 2016. Penetration resistance and soil physical properties in the use of monoculture cultivation land. *Scientific Repository. IPB University* (*in Indonesian*).

Ningsih, W.U., Syafria, H. and Akmal, A. 2022. Effectiveness of palm frond compost on crude protein. crude fiber. and ash content of kumpai grass (*Hymenachne amplexicaulis* (Rudge Nees.) on red-yellow podzolic soil. *Jurnal Peternakan Indonesia* 24:137-142, doi:10.25077/jpi.24.2.137-142.2022 (*in Indonesian*).

Nyamangara, J., Gotosa, J. and Mpofu, S.E. 2001. Cattle manure effects on structural stability and water retention capacity of a granitic sandy soil in Zimbabwe. *Soil and Tillage Research* 62:157-162, doi:10.1016/S0167-1987(01)00215-X.

Olubukola, S.A., Aderemi, O., Tinuke, E.A.D., Akinwunmi, A.H. and Oladipupo, A.J. 2010. Comparing the use of *Tithonia diversifolia* and compost as soil amandements for growth and yield of *Celosia argentea. New York Science Journal* 3:133-138.

Pane, C., Spaccini, R., Piccolo, A., Scala, F. and Bonanomi, G. 2011. Compost amendments enhance peat suppressiveness to *Pythium ultimum, Rhizoctonia solani* and *Sclerotinia minor. Biological Control* 56(2):115-124, doi:10.1016/j.biocontrol.2010.10.002.

Paramananthan, S. 2013. Managing marginal soils for sustainable growth of oil palms in the tropics. *Journal Oil Palm and the Environment* 4:1-16, doi:10.5366/jope.2013.1.

Paulus, J.M., Najoan, J. and Supit, P.C. 2018. The application of gamal local microorganisms on the growth and production of lowland rice using the method of SRI (System of Rice Intensification). *Eugenia* 24:9-14, doi:10.35791/eug.24.1.2018.21648 (*in Indonesian*).

Peng, X., Zhu, Q.H., Xie, Z.B., Darboux, F. and Holden, N.M. 2016. The Impact of manure. straw and biochar amendments on aggregation and erosion in a hillslope Ultisol. *Catena* 136:30-37, doi:10.1016/j.catena.2015.11.008.

Punitha, M.S., Jeyamangalam, F. and Selvam, V. 2021. The effect of farm yard manure combinations with goat manure and compost manure on yield and nutrient uptake of rice. *International Journal of Mechanical Engineering* 6:285-290.

Rasoulzadeh, A. and Yaghoubi, A. 2010. Effect of cattle manure on soil physical properties on a sandy clay loam soil in North-West Iran. *Journal of Food, Agriculture & Environment* 8(2):976-979.

Rigane, K.M. and Medhioub, K. 2011. Assessment of properties of Tunisian agricultural waste composts: Application as components in reconstituted anthropic soils and their effects on tomato yield and quality. *Resources. Conservation & Recycling* 55:785-792, doi:10.1016/j.resconrec.2011.03.012.

Safria, S., Wahyudi, I. and Ali, R. 2017. Effect of gamal leaf bokashi application on nitrogen uptake and yield of sweet corn (*Zea mays* Saccarata) on Sidera Entisol. *Agroland* 243:190-198 (*in Indonesian*).

Singh, G.. Jalota, S.K. and Singh, Y. 2007. Manuring and residue management effects on physical properties of a soil under the rice-wheat system in Punjab, India. *Soil and Tillage Research* 94:229-238, doi:10.1016/j.still.2006.07.020.

Soelaeman, Y. and Haryati, U. 2012. Soil physical properties and production of upland Ultisol soil as influenced by manure application and P fertilization. *Agrivita Journal of Agriculture Science* 34:136-143, doi:10.17503/Agrivita-2012-34-2-p136-143.

Subowo, G. 2010. Strategies for using organic matter efficiently for soil fertility and productivity through empowering soil biological resources. *Jurnal Sumberdaya Lahan* 1:13-25 (*in Indonesian*).

Surya, J.A., Nuraini, Y. and Widianto. 2017. Study of soil porosity in the application of several types of organic materials in Robusta coffee plantations. *Jurnal Tanah dan Sumberdaya Lahan* 4(1):463-471 (*in Indonesian*).

Syahputra, E., Fauzi, F. and Razali, R. 2015. Characteristics of the chemical properties of the Ultisol sub-group in several areas in North Sumatra. *Jurnal Agroteknologi* 4:1796-1803 (*in Indonesian*).

Teka, T.A. 2013. Analysis of the effect of maturity stage on the postharvest biochemical quality characteristics of tomato (*Lycopersicon esculentum* Mill.) fruit. *International Research Journal of Pharmaceutical and Applied Sciences* 3:180-186.

Widodo, K.H. and Kusuma, Z. 2018. Effect of compost on soil physical properties and growth of corn plants in Inceptisols. *Jurnal Tanah dan Sumberdaya Lahan* 5(2):959-967 (*in Indonesian*).

Yu, G.R., Zhuang, J., Nakayama, K. and Jin, Y. 2007. Root water uptake and profile soil water as affected by vertical root distribution. *Plant Ecology* 189:15-30, doi:10.1007/s11258-006-9163-y.

Yulnafatmawita, Adrinal, and Anggriani. 2013. Fresh organic matter application to improve aggregate stability of Ultisols under wet tropical region. *Journal of Tropical Soils* 18:33-44, doi:10.5400/jts.2013.v18i1.33-44.

Zhang, M.K. and Fang, L.P. 2007. Effect of tillage. fertilizer and green manure cropping on soil quality at an abandoned brick making site. *Soil and Tillage Research* 93:87-93, doi:10.1016/j.still.2006.03.016.

Zulkarnain, M., Prasetya, B. and Soemarno. 2013. The effect of compost. manure. and bio-cost on soil properties. growth and yield of sugar cane (*Saccharum officinarum* L.) on Entisols in Ngrangkah Pawon. Kediri. *The Indonesian Green Technology Journal* 2(1):46-52 (*in Indonesian*).

.