International Journal of Agriculture, Environment and Bioresearch

Vol. 08, No. 01; 2023

ISSN: 2456-8643

EFFECT OF SEVERAL TYPES AND DOSES OF COMPOST FROM CELLULOLYTIC MICROBIAL DEGRADATION ON AGGREGATE STABILITY OF ULTISOLS SOIL

Nizar Ulfah[1*], Mieke Rochimi Setiawati[2] and Rina Devnita[2]

[1]Universitas Padjadjaran, Master of Soil Science Program, Faculty of Agriculture,Sumedang 45363, Indonesia

[2]Universitas Padjadjaran, Department of Soil Science and Land Resources, Faculty of Agriculture,Sumedang 45363, Indonesia

https://doi.org/10.35410/IJAEB.2023.5810

ABSTRACT

Ultisolss are one of the marginal soil types that dominate drylands in Indonesia. The main problem of Ultisolss is poor nutrient conditions and low physical properties. The productivity of this soil is low because it has low soil aggregate stability and also has poor biological and physical properties. Research on superior cellulotic microbes in termite nests used as a starter for the decomposition of agricultural waste and changes in the physical properties of Ultisols soil needs to be carried out to determine the effect of applying the type and dose of compost resulting from the degradation of cellulotic microbes to improve the physical properties of Ultisols soil. This experiment was conducted from July 2019 to September 2021 at Ciparanje Experimental Farm, Faculty of Agriculture, Univesitas Padjadjaran. The method used was experiment with Randomized Block Design consisting of 9 treatments and repeated 3 times, namely straw compost 5 tons/ha, 10 tons/ha, 15 tons/ha; sugarcane bagasse compost 5 tons/ha, 10 tons/ha, 15 tons/ha; oil palm empty fruit bunch compost 5 tons/ha, 10 tons/ha, 15 tons/ha. Based on the research of compost degradation results by cellulotic microbes, rice straw compost 15 tons/ha can provide the best aggregate stability results.

Keywords: Aggregate Stability, Soil Physical Properties, Maize, Ultisols.

1. INTRODUCTION

Indonesia is a country that has various types of soils and types of annual and seasonal crops. One of the soil types found in Indonesia is Ultisols. It is one of the marginal soil types that dominates drylands in Indonesia. Ultisols has a wide distribution reaching 38.4 million ha or about 29.7% of the 190 million ha of Indonesia's land area [1]. The main problem on Ultisols besides its poor nutrient condition is also its unfavorable physical properties.

One of the prominent physical properties of Ultisols is the soil texture which is characterized by low dust and high clay content. This textural condition underlies many other problems in Ultisols, including water retention and transmission, soil compaction and root penetration, low aggregate stability, low permeability due to low organic matter content [2]. Low soil aggregates are one of the dangerous physical properties. Besides, the soil structure will be easily destroyed by kinetic rainfall. Soil pore blockage, low infiltration rates can occur due to crushed aggregates. Jatinangor which has a fairly high rainfall per year, potentially facilitates the onset of erosion and runoff [3].

Vol. 08, No. 01; 2023

ISSN: 2456-8643

One way to improve soil physical properties is by applying organic fertilizer. Organic fertilizer needs to be applied in order to optimize the physical, biological and chemical quality of the soil so that plants can grow optimally. The application of organic fertilizers to sand-textured soil will increase inter-particle binding and water binding capacity [4]. Organic fertilizers contain the organic matter which is one of the soil aggregate stabilizing agents. Plant growth can be supported by the influence of aggregates and other soil physical properties.

Soils with sufficient organic matter content have crumbly and stable soil aggregates. Furthermore, the organic matter is also able to create balanced pore space between macro and micro pores for water transmission and retention as well as good soil aeration and drainage [5]. Roots can develop perfectly if there are soil microbes in the decomposition of the organic matter that function to decompose harmful substances and provide nutrients, and runoff can be resolved and infiltration becomes smooth. This can be the reason why Ultisolss can provide satisfactory production if managed properly in accordance with soil conservation rules [6].

The study carried out by Setiawati et al. (2022) reported that giving rice straw compost at a dose of 2 tons/ha produced pakcoy with a wet weight of 130.97 g and a dry weight of 8.45 g, the total population of *Azobacter* sp 10.56 x 10^6 CFU/g is the best treatment in pakcoy plants [7]. In addition to rice straw, there are several agricultural wastes that come from other organic sources that can be utilized, such as empty fruit bunches and sugarcane bagasse. Palm oil Empty bunches (POEB) in Indonesia produces waste that is very abundant, every processor of 1 ton of fresh fruit bunches (FFB) will produce 22-23% of POEB or as much as 220-230 kg of POEB [8]. The potential of the national sugarcane bagasse from the total area of sugarcane plants reaches 2,223,100 tons of sugarcane bagasse per year [9]. The utilization of these wastes needs to be conducted so that the volume of these wastes can be reduced and added the value. Based on this, the application of composts from various agricultural waste materials is needed to know the best effect on plant growth.

Maize (*Zea mays* L.) is one of the staple food crops in Indonesia that is widely utilized in the food, industrial and animal feed sectors. In Indonesia, maize can be produced 10 - 15 t/ha, but productivity in diverse farmlands makes the average yield range from 3.2 - 8 t/ha [10]. Based on the description above, the study of the type and dose of composts resulting from the cellulolytic microbial degradation on the stability of Ultisols soil aggregates in maize plants is an interesting study to be carried out.

2.MATERIALS AND METHODS

This research will be conducted at the Experimental Garden of the Faculty of Agriculture, Universitas Padjadjaran, located in Cileles, Jatinangor, Sumedang Regency, West Java, Indonesia with an altitude of ± 745 meters above sea level from August to September 2021. The material used in this study was Ultisols soils from Jatinangor. The maize seed used was the Bisi-2 variety. The compost was made from agricultural wastes as a treatment consisting of various types of raw materials, namely the rice straw compost, sugarcane bagasse compost and palm oil empty bunches compost, respectively containing C-organic (%): 20.54; 24.46 and 30.58. C/N is

Vol. 08, No. 01; 2023

ISSN: 2456-8643

25.67; 38.22 and 28.85 respectively. N-Total (%) was 0.8; 0.64 and 1.06/ inorganic fertilizers used were urea, SP-36 and KCl as base fertilizers.

This experiment was conducted using the Randomized Block Design method consisting of 9 treatments and 1 control. The polybag used contained 10 kg of air-dried soil. The treatments were:

Tabel 1: Treatment combination of compost type and compost dosage on maize plants

Code	Treatment	Fertilazer dosages kg. ha^{-1}			
		Compost	Urea	KCl	SP-36
		(gram)			
p_0	**Control	0	0	0	0
p_1	*Rice straw compost 5 ton/ha	25	1.5	0.75	0.66
p_2	*Rice straw compost 10 ton/ha	50	1.5	0.75	0.66
p_3	*Rice straw compost 15 ton/ha	75	1.5	0.75	0.66
p_4	*Sugarcane bagasse compost 5 ton/ha	25	1.5	0.75	0.66
p_5	*Sugarcane bagasse compost 10 ton/ha	50	1.5	0.75	0.66
p_6	*Sugarcane bagasse compost 15 ton/ha	75	1.5	0.75	0.66
p_7	*Palm oil empty bunches compost 5 ton/ha	25	1.5	0.75	0.66
p_8	*Palm oil empty bunches compost 10 ton/ha	50	1.5	0.75	0.66
p_9	*Palm oil empty bunches compost 15 ton/ha	75	1.5	0.75	0.66

*Compost is the treatment of compost fertilizer, Urea as a source of N, KCl as a source of K, SP-36 as a source of P.
**Control is the treatment without compost and without inorganic fertilizer.

Soil aggregate stability analysis (wet and dry sieve methods) was conducted at the maximum late generative period of the maize crops and other soil physical properties were analyzed at the Soil

Vol. 08, No. 01; 2023

ISSN: 2456-8643

Research Institute, Bogor, Indonesia.

3.Results and Discussion

3.1Physical Properties of Soil Before Addition of The Organic Matter

The results of the analysis of some soil physical properties before treatment, both before and after tillage can be seen in Table 2. Based on the data presented, in general there is no difference in the criteria for soil physical properties due to processing, except for the aggregate stability index. The increase in soil aggregate stability from less stable to very stable is due to increase the organic matter from the initial soil. According to Damanik et al. (2021), Organic matter is able to bind single soil grains into larger aggregates such as meso aggregates and macro aggregates. [11].

The organic matter content of the initial soil, although categorized as the same (low) percentage after sorting, increased from the initial soil condition by 0.19%. If converted into one hectare of soil 20 cm deep with a BV of 1.04-1.06 g.cm^{-3}, then the amount of addition is quite a lot, reaching 37 - 45 tons of dry organic matters.

Table 2: The results of the analysis of soil physical properties before the application of organic material and after treatment

Treatment	C-organic	Criteria	*N*-Total (%)	Criteria	C/N	Criteria	Aggregates (%)	Aggregate Stability Index	Criteria
Initial soil	1.06	Low	1	Very Low	11	Medium	46.03	48.96	Not Steady
No compost application	1.25	Low	0,08	Very Low	15.00	High	55.67	96.87	Very Steady

*) Source: Indonesian Soil Research Institute, Bogor.

The organic matter increases due to the decomposition process by plant residues or vegetation on the soil surface. Soil cultivators have an influence on the decomposition process in the soil, so that the organic matter in the soil increases. The influence of tillage on the decomposition process in the soil will cause the organic matter in the soil to change as well. [13].

The physical quality of the final soil in Jatinangor is low. Low organic matter contents, fast drainage pores or macro pores that are usually filled with air are also low, and the percent of aggregation is less than 50%. The percentage of clay content in the Jatinangor Ultisols soil is known to be 75%. Soils with a high clay content require a lot of the organic matter to stabilize the soil aggregates. The organic matter is also expected to increase the percentage of soil macro pores and can increase the infiltration rate.

Vol. 08, No. 01; 2023

ISSN: 2456-8643

3.2 Physical Properties of Soil After Addition of Organic Matter

Some of the soil physical and chemical properties analyzed after the organic matter application were the organic matter content and aggregate stability.

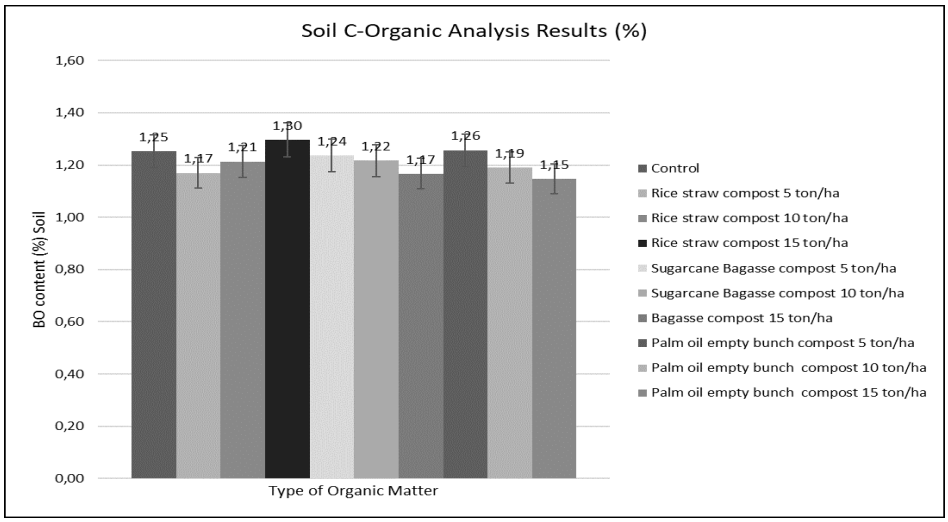

Figure 1: Effect of several types of the organic matter on the organic matter content of the Ultisols soil

3.2.1 The Organic Matter Content

The effect of giving several types of the organic matter to maize plants can be seen in Figure 1. In general, compared to the control treatment of 15 tons/ha of jermai composts and 5 tons/ha of palm oil empty bunches compost, there is an increase in the amount of the organic matter compared to without composts. This is expected to happen because the soil organic matter has been mineralized. The mineralization is the process of releasing nutrients derived from soil biochemical processes that convert the organic matter into inorganic, while indirect effects can cause the accumulation of the soil organic matter to improve soil physical properties [12]. Microbes need N to synthesize proteins in forming themselves.

In the analysis results, although each additional dose of the organic matter in general each type of composts did not show an increase in the number of doses given, it was seen that the organic matter increased from the initial soil. At three months after treatment, the organic matter content in straw composts increased compared to other treatments by 1.3% compared to the control and other treatments. After straw compost, the highest increase in soil organic matter was followed by composted oil palm empty fruit bunches (1.26%), sugarcane bagasse compost 5 tons/ha (1.24%). In sugarcane bagasse and empty palm bunches, it can be seen that the organic matter content of the more doses given tends to slope. In rice straw, the organic matter content of the more doses given tends to increase.

Vol. 08, No. 01; 2023

ISSN: 2456-8643

3.2.2 Aggregate Percentage

The average percentage value of Ultisols aggregates after the provision of several types of organic materials for 3 months can be seen in Figure 2 below.

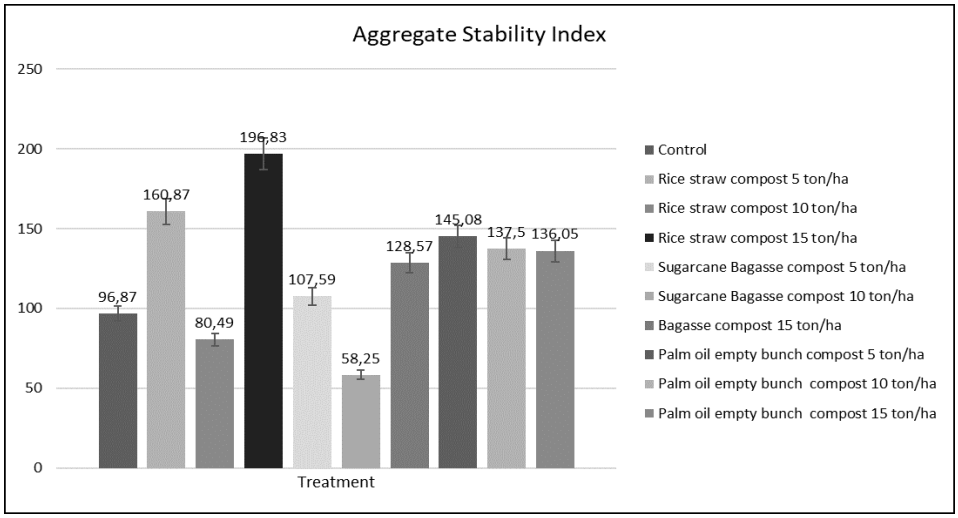

Figure 2: Effect of Several Types of Organic Materials on Ultisols Aggregates

In Figure 2 we can see that after the provision of organic matter, the percentage value of soil aggregates in the third month, namely during the maximum generative period, looks significantly different in the treatment of 15 tons/ha of straw compost, which is 196.83. In the treatment of 10 tons/ha palm oil reservoir compost and 15 tons/ha palm oil empty bunches compost are not significantly different. It is suspected that from these two types of organic materials the weathering process that occurs is not perfect, unlike the 15 tons/ha rice straw composts which have a high *N*-content and moisture content.

In general, the average provision of the organic matter in Ultisols soils has improved. A soil is said to be very stable when it has an aggregate stability rating of 80 - 200. In this study, it is known that there is a change in the physical properties of soil aggregates from the initial soil that is less stable to very stable. The average increase in the soil organic matter from the initial soil to each compost treatment was 75.85%.

The content of the soil organic matter increases with time up to 3 months after application in line with the level of the organic matter added and the humification process that occurs. According to Yulnafatmawita (2008), the weathering of the organic matter in addition to producing mineral materials and simple compounds, also produces colloidal humus which is very instrumental as a soil grain agent. Increasing soil organic matter will increase aggregate stability especially at 0-10 cm depth. [14]. Among the nine organic materials given, the highest aggregate stability was in straw composts at 10 tons/ha. This is an indication that the rice straw can be used as the most important soil aggregate stabilizer during the young growing season or for 3 months (maximum generative period). The *N*-content of 15 tons/ha of rice straw composts was 14.33%.

Vol. 08, No. 01; 2023

ISSN: 2456-8643

The high *N*-content fosters the formation of many microbes so that the weathering process becomes faster. Advanced weathering will produce humus, a compound that acts as the main aggregator [5]. After the third month, it is possible that the weathering process will continue. So, the same amount of the application will have different results from the first 3 months.

4.CONCLUSION

The application of several types of the organic matter is able to increase the content of the Ultisols soil organic matter in maize plants. Rice straw composts 15 tons/ha respond faster to the increase in the soil organic matter content, followed by palm oil empty bunches compost 5 tons/ha, and finally sugarcane bagasse 15 tons/ha. The values of the aggregate stability index are 196.83; 145.08; 128.57, respectively.

The organic matter content in each treatment increased from the initial soil. The average increase of the soil organic matter from the initial soil to each compost treatment was 75.85%. The high organic matter influenced the high aggregate stability index. The aggregate stability index of all treatments increased in the late generative period of maize plants.

REFERENCES

[1] E. R. Masni, Bintang, and M. Purba, "Effect of The Mineral and Organic Matter Interactions on Ultisols Chemical Properties and Mustard Crop Production," *Online J. Agrotechnology*, vol. 3, no. 4, pp. 1489–1494, 2015.

[2] Yulnafatmawita, R. A. Naldo, and A. Rasyidin, "Analysis of Physical Properties of Ultisols Three Years after Fresh Organic Matter Application in The Wet Tropics of West Sumatra," *J. Solum*, vol. 9, no. 2, pp. 91–97, 2012.

[3] S. R. Center, "Technical Guidelines for Soil Physics Analysis," Bogor, 2022.

[4] Sutanto, *Organic Agriculture: Toward Sustainable Alternatof Fan Agriculture*. 2002.

[5] Yulnafatmawita, "The Effect of Providing Several Types of Organic Materials on The Stability of Ultisols Soil Aggregates in Limau Manis," *Solum J.*, vol. 5, no. 1, pp. 7–13, 2008.

[6] Fitriatin, B. Batalie, A. Pratama, Mulyani, and Ovianti, "Soil Aggregate Stability, P-Solubilizing Fungus Population and Maize Yield as Affected by P-Solubilizing Microbial Biofertilizer and P-Fertilizer in Ultisols," *Soilrens*, vol. 16, no. 1, 2018.

[7] M. R. Setiawati, C. Salsabila, P. Suryatmana, R. Hindersah, and N. N. Kamaludin, "Effect of Agricultural Waste Compost on Azobacter sp. Population, C-organic, N-Total, N-uptake and Yield of Pakcoy in Jatinangor Inceptisol Soil.," *J. Agric.*, vol. 22, no. 3, pp. 178–188, 2022.

[8] Salmina, "Study of Palm Oil Empty Bunch Waste Utilization by The Community in Jorong Koto Sawah Nagari Ujung Gading Lembah Melintang District," 2017.

[9] M. Sutikno and N. Sari, "The Effect of Alkali Pretreatment and Acid Hydrolysis on Sugarcane bagasse-Reduced Sugar Content," *J. Ind. Technol. Agric. Prod.*, vol. 20, no. 2, 2015.

[10] Sutoro, "Agronomic Determinants of Maize Productivity," *Food Crop Sci. Technol.*, vol. 10, no. 139–46, 2015.

Vol. 08, No. 01; 2023

ISSN: 2456-8643

[11] A. Damanik, Refliaty and Y. Achnopa, "Analysis of The Stability of Ultisol Aggregates at Several Levels of Slope and Different Ages of Palm Oil Plants (Case Study At PT Mekar Agro Sawit, Bathin XXIV District, Batanghari Regency, Jambi Province)," *Agroecotenia. J.*, vol. 4, no. 2, 2021.

[12] Atmojo and S. W., "The Role of Organic Matter on Soil Fertility and Its Management," *J. Agrotechnology*, vol. 1, no. 10, pp. 10–18, 2003.

[13] Gusmini, Yulnafatmawita and A.F. Daulay, "Effect of Several Types of Organic Materials on Increasing The Nutrient Content of N, P, K Ultisols Experimental Garden FAPERTA UNAND Padang", *Solum. J.*, vol V, no 2, 2008

[14] B. S. Utomo, Y. Nuraini, and Widianto, "Assessment of Soil Aggregate Stability in The Application of Several Types of Organic Materials in Robusta Coffee Plantations", *Journal of Soil and land resources.*, vol 2, no 1 : 111 0 117, 2015