AGROLAND: The Agricultural Sciences Journal
Vol. 7, No. 2 December (2020), 99 - 105
P-ISSN : 2407- 7585 & E-ISSN : 2407- 7593, Published by Tadulako University

Original Research **Open Access**

EFFECT OF COMPOST DOSES ON SOIL RESILIENCE IN PALU VALLEY

Danang Widjajanto[1)], Uswah Hasanah[1)], Imam Wahyudi,[1)] St Sukmawati[1)], Sufyan[1)]

[1)]Soil Science Laboratory, Faculty of Agriculture, Tadulako University

Correspondence author's: Danang Widjajanto
Email **:** danang1965@untad.ac.id

Submit: 1 December 2020, Revised: 8 December 2020, Accepted: December 2020

ABSTRACT

Applying organic matter to the soil surface is an effective effort to increase soil resilience in the Palu valley, which is classified as low. This study aimed to determine: 1) the effect of several doses of compost on the physico-chemical properties of the soil, 2) the correlation between the percentage of organic carbon and total nitrogen in the soil to several physico-chemical properties of the soil. The research was based on a randomized block design in a greenhouse of the Faculty of Agriculture, Tadulako University, Palu. Compost uses raw materials for plantain stems (*Musa textilia*) and leaves of Gamal (*Gliricidia sepium*). The compost doses used in the experiment consisted of 0%, 1%, 2%, 3%, 4%, and 5% of the weight of air-dry soil, respectively. The treatment was repeated three times. The results showed that compost application significantly affected soil content weight, total porosity, saturated hydraulic conductivity, field capacity moisture content, percentage of organic carbon, total nitrogen, and cation exchange capacity. The correlation test results showed a powerful relationship between the percentage of organic carbon or total soil nitrogen to other soil physico-chemical properties observed in the experiment.

Keywords:, Compost, Soil resilience, and Soil structure.

INTRODUCTION

Soil erosion is a global threat that can harm the physico-chemical properties of soil. Continuous exposure to rainwater can cause structural damage to the soil surface. The soil is getting denser, the volume of soil pore space is getting lower, and the groundwater storage capacity is getting smaller. Even in the long term, catastrophic soil erosion can lead to desertification.

The transport of organic matter to the surface of the soil due to erosion can gradually cause a decline in soil health. The worsening of the dry land ecosystem can be triggered by the low content of organic matter and water availability in the soil (Widjajanto and Hasanah, 2019).

In developing a sustainable agricultural system, organic agriculture is seen as an alternative solution to the right problem to deal with land degradation. Organic matter can play a role in repairing damaged soil structures and positively impact financial benefits in many farming systems, such as food crop cultivation systems on dry land, agroforestry, and smallholder plantations (Widjajanto and Gailea, 2008).

The existence of compost as a complement to inorganic fertilizers is a form of local wisdom that has long been recognized in the plant cultivation system by the Indonesian nation's ancestors. The use of compost has contributed to improving soil quality and crop production in the next planting period in several ways, such as increased availability of plant nutrients, aggregate stability, soil porosity, available water volume, and cation exchange capacity in the soil. Blanco-Canqui & Benjamin (2015) stated that organic matter to the soil surface could maintain a good soil structure for plant growth. This also has implications for its ability to reduce the risk of damage to mechanical properties and improve groundwater characteristics.

The use of compost to improve the quality of soil fertility has been studied by Nurhadiah and Sutra (2017). The use of compost as an ameliorant in soils with low fertility status can improve soil physical, chemical, and biological properties. Increased soil cation exchange capacity as a consequence of compost can affect the availability of plant nutrients.

Widodo and Kusuma (2018) suggest that compost can improve soil physical properties and plant production. Soil becomes loose, and plant root growth increases with increasing dose of administration.

Gupta et al. (1987) and Dexter (1988) suggest that the soil structure became more stable due to the application of organic matter. Organic matter can affect the degree of change in soil pore size distribution in sandy and clayey soils. The risk of compaction and worsening groundwater flow behavior due to the influence of external stresses can be reduced through the application of organic matter in the soil.

The transport of organic matter by the downward movement of groundwater and erosion processes on sandy soils in the Palu Valley can cause surface groundwater's binding capacity to decrease. Trisno et al. (2016) stated that the sandy soil texture and low organic matter content cause groundwater conductivity to be at a moderate - very fast level and the capacity to hold groundwater at a low - moderate level. The addition of organic matter can improve the soil structure in the area.

The abundance of organic waste availability as raw material for composting is considered interesting to research to improve the quality of inceptisols in the Palu Valley. The research objectives were: 1) to determine the effect of several doses of compost on the physico-chemical properties of the soil 2) to determine the relationship between the organic carbon or nitrogen content of the soil physico-chemical properties.

MATERIALS AND METHODS

The research was conducted in greenhouses and the Soil Science Laboratory of the Faculty of Agriculture, Tadulako University from November 2017 to June 2018. The tools used are equipment for the preparation of soil samples used in the experiment, bioreactors for composting, and laboratory equipment to support the analysis of physical properties and soil chemistry. The materials used in the experiment were compost produced from the decomposition of plantain stems (*Musa textilia*) and leaves of Gamal (*Gliricidia sepium*), EM4 solution, urea fertilizer, sugar, and sufficient water. The results of the analysis of soil and compost used as research material are presented in Table 1.

This study used a randomized block design (RBD) with six treatments of compost. The soil used in the study was Inceptisols Sidera in Sigi Regency, which was taken at a depth of 0-20 cm. The research was repeated three times so that overall, in the study, there were 18 experimental pot units. The treatments used in the experiment consisted of:

P0 = Control (without composting)

P1 = Compost application at a dose of 1% of the weight of the air-dry soil
P2 = Compost with a dose of 2% of the weight of air-dry soil
P3 = Compost application at a dose of 3% of the weight of air-dry soil
P4 = Compost with a dose of 4% of the weight of the air-dry soil
P5 = Compost with a dose of 5% of the weight of the air-dry soil

Air-dried soil samples that passed a 2 mm diameter sieve were used in the pot experiment. A sample of 5 kg of soil in each prepared experimental pot is then mixed with compost according to the planned dose. Every 1% compost added to the experimental pot is assumed to be equivalent to 11.5 tones/ha given directly in the field. The duration of the soil incubation in the study was carried out for three months. During the incubation period, the pots were watered to the limit of field capacity with a frequency of every five days. Observation of soil's physico-chemical properties in the laboratory was carried out after the end of the incubation period in the greenhouse. The data from the observations were analyzed using variance, and if it showed a real difference between the treatments, then it was continued with the Tukey's honestly significant difference (HSD) test at the 5% test level.

Table 1. Physical and Chemical Properties of the Soil and Compost Used in This Study

Variable	Value	Unit	Criteria
Soil			
pH H_2O (1 : 2.5)	6.12	-	Slightly acid
pH KCl (1 : 2.5)	5.48	-	
Sand	67.50		
Silt	15.52	%	Sandy loam
Clay	16.98		
C-Organic	1.43	%	Low
N-Total	0.08	%	Very low
Compos			
C-Organic	34.40	%	Suitable
C/N	16.23		Suitable
pH H_2O (1:2,5)	5.92		Suitable
Water content	18.52	%	Suitable

RESULTS AND DISCUSSION

The application of compost with different doses showed a significant effect on the soil's physical properties such as soil bulk density, porosity, hydraulic conductivity, and field capacity moisture content (Table 2).

The decrease in soil content weight in line with the increase in compost application dosage causes increased total porosity, saturated hydraulic conductivity, and water content in field capacity. Kobierski et al. (2018) stated that organic matter could improve surface soil aggregates' structure and stability. In this condition, the destructive power of water to the surface soil can be reduced. The high stability of soil aggregates can increase soil penetration resistance and reduce the risk of compaction.

The treatment of 5% compost (P5) caused changes in the total soil porosity to significantly increase by 16.77% compared to without compost treatment (P0). The use of compost derived from plantain stems and Gamal leaves with a low C / N ratio can increase the formation of micro-mesosized pore spaces. Bashir et al. (2016) and Glab et al. (2018) argue that the type of raw material and the maturity of the organic material used as an ameliorant significantly affect the degree of change in soil physical properties causes on sandy soils. The use of organic matter with a low C / N ratio causes the formation of soil pore spaces with a size of <50 µm. On the other hand, the use of organic matter, which has a high C / N ratio, causes the formation of pore spaces > 500 µm in size.

Table 2. Effect of Compost on Soil Physical Properties

Treatment	Bulk density (g/cm^3)	Total Porosity (%)	Saturated Hydraulic Conductivity (cm/hour)	Field Capacity Water Content (% w/w)
P0	1.34 *a*	33.52 *c*	3.84 *c*	12.79 *c*
P1	1.32 *ab*	35.24 *bc*	4.41 *bc*	13.31 c
P2	1.30 *ab*	36.79 *abc*	4.53 *bc*	14.31 *bc*
P3	1.29 *ab*	36.96 *abc*	5.35 *ab*	15.90 *ab*
P4	1.27 *b*	38.07 *ab*	5.99 *a*	17.19 *ab*
P5	1.26 *b*	39.14 *a*	6.16 *a*	18.05 *a*
Treatment	Soil fill weight (g/cm^3)	Total Porosity (%)	Saturated Hydraulic Conductivity (cm/hour)	Water Content Field Capacity (% w/w)
P0	1,34 *a*	33,52 *c*	3,84 *c*	12,79 *c*
P1	1,32 *ab*	35,24 *bc*	4,41 *bc*	13,31 c
P2	1,30 *ab*	36,79 *abc*	4,53 *bc*	14,31 *bc*
P3	1,29 *ab*	36,96 *abc*	5,35 *ab*	15,90 *ab*
P4	1,27 *b*	38,07 *ab*	5,99 *a*	17,19 *ab*
P5	1,26 *b*	39,14 *a*	6,16 *a*	18,05 *a*

Note: Numbers accompanied by the same letter show that they are not significantly different Tukey' HSD test.

At a dose of 5% (P5), application compost significantly increased the saturated hydraulic conductivity by 60.42% compared to the treatment without compost (P0). The increase in groundwater conductivity can be caused by the increasing volume of the total soil pore space. Jusman et al., (2018) stated that the application of organic matter has a significant effect on changes in the total pore space volume and hydraulic conductivity of inceptisols. The water movement on sandy soil media tends to decrease in line with the increase in the volume of micro-sized pore spaces. On the other hand, water movement on a clay-textured soil medium tends to increase in line with the increase in macropore space volume.

The groundwater content of the field capacity in treatment P5 showed an increase of 41.13% compared to treatment P0. The increase in the total pore space volume and the increasing dose of compost causes the meso and micro-sized pore spaces to play an essential role in holding water in the field capacity. In conditions of limited groundwater content, meso and micropore spaces have an essential role in maintaining water availability in the soil. Ramos (2017) has suggested that composting positively correlates with increasing the capacity of available groundwater. Changes significantly influence the increased ability to hold sand-textured groundwater in field capacity conditions in soil structure. The pore space size distribution in sandy soil, which was initially dominated by macropore spaces, can change to being dominated by meso and micro pore spaces.

In high water stress conditions, the high organic carbon content can also contribute to high water-binding on sandy soils. This is due to the ability of organic matter to bind water in a higher amount than the soil particles' ability.

Composting is an alternative to increasing carbon and nitrogen sources in the soil. The organic carbon content of 34.40% and a C/N ratio of 16.23 indicates that the compost material has a maturity level suitable for ameliorant material. The effect of composting on several chemical properties of soil is presented in Table 3.

The content of organic carbon and soil nitrogen shows a very strong correlation with changes in the physico-chemical properties of sandy loam textured soils. A robust correlation to the observation variables of soil fill weight, pore space volume, saturated hydraulic conductivity and water content, field capacity, and cation exchange capacity as a result of composting is an indicator that the presence of carbon and nitrogen elements in the soil has an essential role in influencing the level of resilience soil.

Rawls et al., (2003) and Hasanah (2008) suggest that the increase in organic carbon content can lead to increased groundwater retention in sandy loam textures, in contrast to reducing water retention in clay textured soils. The stable soil structure causes the soil to be more resistant to mechanical stress conditions and high groundwater.

Organic carbon has a vital role in increasing the biomass of microorganisms in the soil. The diversity of microorganisms in the soil is an important indicator to determine soil health-qualities. Magesan et al. (2000) argued that there is a close relationship between the C / N ratio of soil and the soil's physico-chemical properties. The availability of sufficient organic carbon and nitrogen in the soil is required for various enzymatic processes by microorganisms in relation to changes in soil properties. The incubation period of organic matter, which has a low C/N ratio in the soil for three months, is sufficient for influencing various physical, chemical, and biological soil behaviors.

Table 3. Effect of compost on several soil chemical properties.

Treatment	C-Organic (%)	N-Total (%)	pH H_2O	CEC (me/100 g)
P0	1.48 *d*	0.10 *c*	6.07	13.83 *c*
P1	1.64 *d*	0.13 *bc*	6.10	18.58 *b*
P2	2.22 *cd*	0.16 *b*	6.11	22.98 *ab*
P3	2.98 *bc*	0.20 *a*	6.20	25.18 *a*
P4	3.32 *ab*	0.21 *a*	6.20	26.37 *a*
P5	4.07 *a*	0.23 *a*	6.20	28.11 *a*

CONCLUSION

Giving compost to Sidera inceptisols significantly affects soil content weight, total porosity, saturated hydraulic conductivity, field capacity moisture content, percentage of organic carbon, total nitrogen, and soil cation exchange capacity (CEC).

The correlation test results show a powerful relationship between the percentage of organic carbon or total nitrogen in the soil-to-soil content weight, total porosity, saturated hydraulic conductivity, the water content in field capacity, pH, and soil cation exchange capacity (CEC).

REFERENCES

Bashir, K., S. Ali., S.S. Ijaz., and I. Ahmad. Effect of organic amendments on distribution, stability and carbon concentration of soil aggregates. 2016. Pak. J. Agri. Sci., Vol. 53 (4): 955-961.

Blanco-Canqui, H., and J. G. Benjamin. Impacts of soil organic carbon on soil physical behavior. John Wiley & Sons, Ltd. 2015, Page:11–40.

Dexter, A. R. Advances in characterization of soil structure. Soil and Tillage Research, 1998. 11(3–4):199–238.

Głąb, T., A. Żabiński, U. Sadowska, K. Gondek, M. Kopeć, M. Mierzwa-Hersztek, and S. Tabor. Effects of co-composted maize, sewage sludge, and biochar mixtures on hydrological and physical qualities of sandy soil. Geoderma. 2018, 315:27–35.

Gupta, S. C., E. C. Schneider, W. E. Larson, and A. Hadas. Influence of corn residue on compression and compaction behavior of soils. Soil Science Society of America Journal. 1987 51(1):207–212.

Hasanah, U. 2008. Pengaruh bahan organik dan kalsium terhadap struktur mikro tanah. J. Agroland. 2008 15 (3) : 156 – 165.

Jusman, J., D. Widjajanto, dan U. Hasanah. Beberapa sifat fisika inceptisol watutela dalam kaitannya dengan pemberian bahan organik dan suhu pemanasan. e-J. Agrotekbis. 2017 5(2): 144-151.

Kobierski, M., K. Kondratowicz-Maciejewska, M. Banach-Szott, P. Wojewódzki, and J. M. Peñas Castejón. Humic substances and aggregate stability in rhizospheric and non-rhizospheric soil. Journal of Soils and Sediments. 2018 18(8):2777–2789.

Latifah, O., O. H. Ahmed, and N. M. A. Majid. 2018. Soil pH buffering capacity and nitrogen availability following compost application in a tropical acid soil. Compost Science and Utilization. 2018 26(1):1–15.

Magesan, G. N., J. C. Willi amson, G. W. Yeates, and A. R. Lloyd-Jones. 2000. Wastewater C:N ratio effects on soil hydraulic conductivity and potential mechanisms for recovery. Bioresource Technology. 2000 71(1):21–27.

Nurhadiah dan O. Sutra. Pengaruh kompos batang pisang terhadap pertumbuhan dan hasil tanaman terung (*Solanum melongena*, L.) pada Tanah Podsolik Merah Kuning. PIPER, 2017 13: 83 – 90.

Ramos, M. C. Effects of compost amendment on the available soil water and grape yield in vineyards planted after land levelling. Agricultural Water Management . 2017 191:67–76.

Rawls, W. J., Y. A. Pachepsky, J. C. Ritchie, T. M. Sobecki, and H. Bloodworth. Effect of soil organic carbon on soil water retention. Geoderma. 2003 116(1–2):61–76.

Trisno, T., D. Widjajanto, and U. Hasanah. Pengaruh kompos kotoran sapi terhadap beberapa sifat fisik entisol Lembah Palu. e-J. Agrotekbis. 2016 4 (3):288-294.

Widjajanto, D., and U. Hasanah. Land resource management strategy for the sustainability of the upper watershed of Palu (case study of Miu sub watershed in Sigi regency). Agroland:The agriculture science journa. 2019 6 (1):34-43.

Widjajanto, D., dan R. Gailea. Kajian pengembangan agroforestri untuk pengelolaan Daerah Aliran Sungai Toranda, Kecamatan Palolo, Kabupaten Sigi, Propinsi Sulawesi Tengah. J. Agroland. 2008 15 (4):264 –270.

Widodo, K.H., dan Z. Kusuma. Pengaruh kompos terhadap sifat fisik tanah dan pertumbuhan tanaman jagung di inceptisol.

Jurnal Tanah dan Sumberdaya Lahan. 2018 5 (2):959 – 967.

Xiaohou, S., T. Min, J. Ping, and C. Weiling. Effect of EM kompos application on control of secondary soil salinization. Water Science and Engineering. 2008 1(4):99–106.

Yang, R., Y. Z. Su, T. Wang, and Q. Yang. 2016. Effect of chemical and organic fertilization on soil carbon and nitrogen accumulation in a newly cultivated farmland. Journal of Integrative Agriculture. 2016 15(3):658–666