

Revamping of entisol soil physical characteristics with compost treatment

Sumono, S P Loka and D L S Nasution

Department of Agricultural Engineering, Faculty of Agriculture, Universitas Sumatera Utara. Jl. Prof. Dr. A. Sofyan No.3 Kampus USU Medan 20155
E-mail: sumono@usu.ac.id

Abstract. Physical characteristic of Entisol soil is an important factor for the growth of plant. The aim of this research was to know the effect of compost application on physical characteristics of Entisol soil. The research method used was experimental method with 6 (six) treatments and 3 replications of which K1= 10 kg Entisol soil without compost, K2 = 9 Kg Entisol soil with 1 kg compost, K3= 8 kg Entisol soil with 2 kg compost, K4= 7 kg Entisol soil with 3 kg compost, K5= 6 kg Entisol soil with 4 kg compost and K6= 5 kg Entisol soil with 5 kg compost. The observed parameters were soil texture, soil organic matter, soil thickness, porosity, soil pore size, soil permeability and water availability. The results showed that the Entisol soil texture was loamy sand texture, the value of soil organic matter ranged from 0.74% to 4.69%, soil thickness ranged from 13.83 to 20.16 cm, porosity ranged from 16% to 37%, soil pore size ranged from 2.859 to 5.493 μm , permeability ranged from 1.24 to 5.64 cm/hour and water availability ranged from 6.67% to 9.12% by each treatment.

1. Introduction

Agricultural development in Indonesia has many constraints due to the conversion of productive land into non-agricultural activities. In an effort to expand agricultural land, land use leads to marginal land which is less fertile and not supporting in matter of soil physical properties. Therefore, it is necessary to improve the physical, chemical and biological properties of the soil with the addition of organic materials and adequate water supply so that marginal land can be used for agricultural enterprises. Entisol soil is one of marginal land that characterized by loose soil consistency, low level of aggregation, easy to eroded, and low nutrient and organic matter content [1]

Organic Matter has the main role in maintaining soil quality. In the condition of low soil organic matter, the addition of compost is very recommended to increase soil organic matter and maintain soil quality. The application of compost influences soil quality and will reduce chemical fertilizer needs, increasing plant growth, increasing soil biomass and microbes activity [2]

Response of compost proportion on soil will depend on composition of compost, soil type, and compost ratio to soil, which also lead to different maximum enhancement in improving soil physical properties. It is necessary for the study to determine the exact proportion of composting Entisol soil by some compost treatment to soil in improving soil physical properties and the suitability for plant growth.



2. Materials and Methods

The material used in this study is sample of Entisol soil from PTPN II Tanjung Garbus. Compost is used as a addition of soil in hoping to increase soil fertility. This study uses compost biotic product Ipteks Bagi Inovasi dan Kreativitas Kampus (IBIKK) Compost Center Universitas Sumatera Utara. Polybag is used as the container for compost and soil, the labels are used to mark on both the ring samples and polybag, and water is used to stabilize the soil.

2.1 Research Methods

The research method used is an experimental method in Greenhouse and soil analysis in the Laboratory of Research and Technology Faculty of Agriculture, Universitas Sumatera Utara with 6 treatments and 3 replications on each treatment, where 10 kg Entisol soil (control / K1) as first treatment, 9 kg Entisol soil and 1 kg compost (K2) as second treatment, 8 kg Entisol soil and 2 kg compost (K3) as third treatment, 7 kg Entisol soil and 3 kg compost (K4) as fourth treatment, 6 kg Entisol soil and 4 kg compost (K5) as fifth treatment and 5 kg Entisol soil and 5 kg compost (K6) as sixth treatment.

Entisol soil sample and compost are dried in room temperature. Each dried soil and dried compost was crushed and sieved using 10-mesh-siever. Then, the sieved soil and compost were mixed and stirred evenly. Soil treatment and compost by each treatment were poured into 10 kg polybag. The mixture of soil and compost were sprinkled in polybags for soil stabilization. The soil was watered continuously until it was steady. The soil criterion was stable when there was no reduction in soil thickness and constant drained water. Soil samples were taken after the soil reached field capacity using the ring sample to determine the soil physical characteristics in the laboratory.

Test in the Laboratory of Research and Technology Faculty of Agriculture includes measuring soil texture using hydrometer method and analyzed using USDA triangle, analyzing C-organic material by Walkley & Black method, analyzing bulk density, particle density, soil porosity, soil thickness, and soil permeability by Constant Head Test method. Moisture content of field capacity and permanent wilting point and water availability are analyzed by pF test 2.54 (field capacity) and pF 4.2 (permanent wilt point) in Palm Oil Research Centre. Soil pore size analyzed with SEM (Scanning Electron Microscope) and Research parameters were soil texture, soil organic matter, bulk density, particle density, porosity, permeability, the moisture content of field capacity, water available, thickness of the soil and pore size.

3 Results and discussion

3.1 Soil texture

From the analysis of soil texture (Table 1), it is known that Entisol soil texture is loamy sand, which means sand fraction is more dominant than the fraction of silt and clay. The soil texture was determined using USDA. Knowing the texture of the soil will facilitate in the improvement of physical properties and soil fertility.

Table 1. Results of the analysis of soil texture

Soil Entisol	Fraction			Soil texture
	Sand(%)	Silt (%)	Clay (%)	
K ₁	85.84	5.89	8.26	Loamy sand
K ₂	85.84	6.56	7.60	Loamy sand
K ₃	84.56	7.94	7.49	Loamy sand
K ₄	83.89	7.94	8.16	Loamy sand
K ₅	80.56	11.94	7.94	Loamy sand
K ₆	78.56	15.28	6.16	Loamy sand

Table 1 shows that addition of compost treatment decreases the percentage of sand fraction and increase the amount of silt fractions. More porous a soil (the higher fraction of sand) will easier roots to penetrate and easier water and air to circulate, but water will easily lost from the soil, and otherwise. The sand textured soils have small surface area making it difficult to hold water and nutrients

3.2 Soil Organic Matter

Organic matter analysis results are presented in Table 2, the treatment K6 had the biggest organic matter content of 4.69% with moderate criteria, whereas K1 treatment had the lowest organic matter content of 0.74% with very low criteria, from [12] criteria carbon organic <1% (very low), 1-2% (low), 2.01-3 % (medium), 3.01-5% (high) and >5% (very high). This is caused by the higher ratio of compost in each treatment, will higher organic content of the soil and it increases soil fertility and improve soil physical and chemical properties, especially in soils with low nutrient such as Entisol

Table 2. Results of analysis of soil organic matter content

Treatment	Levels of C-organic(%)	Organic matter content(%)	Criterion
K ₁	0.43	0.74	Very low
K ₂	0.93	1.60	Very low
K ₃	1.29	2.22	Low
K ₄	1.88	3.24	Low
K ₅	2.31	3.98	Medium
K ₆	2.71	4.69	Medium

Neata, et al [2] reported that in areas where the soil organic matter content is low, the use of compost in agriculture is highly recommended to increase soil organic matter content and to improve and maintain soil quality.

3.3 Soil thickness

Soil thickness measurement results in a 40 cm x 50 cm and 23 cm diameter polybag size in wet conditions (field capacity of measuring drainage) free (Table 3).

Table 3. Results of the soil thick with revamping Entisol compost

Treatment	Soil thickness (cm)
K1 (Control)	13.83
K2	15.25
K3	16.67
K4	17.29
K5	18.70
K6	20.16

From Table 3, it is known that soil without compost had the lowest soil thickness which was 13.83 cm thickness and the highest is the treatment K6 which was 20.16 cm thickness. This is because the K1 are denser than the other treatment, where compost will friabling the soil and improve the ability of soil to retain water. Solids will reduce the water holding capacity, reducing the air content, providing major physical barriers on root penetration, reducing its ability to harvest water, air and nutrients. Israelsen and Hansen [3] stated that soil thickness will inhibit the regulation of air from soil pores that retarding water movement and it will reduce permeability rate.

3.4 Bulk density

The measurement results soil bulk density, soil particle density, and porosity can be seen from this table below

Table 5. The soil bulk density, soil particle density, and porosity

Treatment	Bulk density(g/cm ³)	Particle density(g/cm ³)	Porosity(%)
K1	1.44	1.70	16
K2	1.24	1.52	19
K3	1.15	1.48	23
K4	1.07	1.43	26
K5	0.97	1.35	29
K6	0.83	1.31	37

Table 5 showed that soil bulk density measurement results are different in each treatment. The value of the highest Entisol soil density was 1.44 g/cm³(K1) and the lowest was 0.83 g/cm³(K6). The variation in bulk density is due to relative proportions of organic particles and inorganic solids and soil porosity. It's suitable to Xin statement that compost application will decrease soil bulk density significantly and increase porosity [4]

Hossain et al stated that variety of bulk density value due to the relative proportion of anorganic solids dan soil porosity. Most of mineral soil bulk density soil is about 1,0 and 2,0 g/cm [5]

3.5 Particle density

It can be seen from Table 5 that the treatment K6 has the lowest density soil particles value of 1.31 g/cm³. This result is directly proportional to the mass density of Entisol soil. The using of high compost comparison value will lower bulk density as well as the particle density. The more organic content contained in the soil, the smaller the value of particle density

Treatment K1 (control) particle density value is 1.70 g/cm³ which below the average value of the density of mineral soil particles in the field that is 2.65 g/cm³. This is caused by the texture of the Entisol is loamy sand which has a lot of pore texture macro or coarse pores, causing a small volume of soil density. Besides, at the beginning of soil in a state trial disrupted due to be crushed and sieved to obtain a uniform grain before it was poured in a polybag, then land needs through a process of consolidation and density is not the same as the conditions on the ground (soil structure is different)

3.6 Soil porosity

Results from Table 5 showed the highest soil porosity at 37% (K6) and the lowest (K1) at 16%. Porosity of K6 has a higher porosity for the K6 has a ratio of bulk density and particle density that is lower than other treatments, where the high and low value bulk density and particle density is influenced by organic matter soil so that the soil containing organic matter has a high porosity, too. The increase in soil organic matter content can increase the porosity of the soil so that it will further strengthen the structure and texture of the soil as well as the development of surface soil biota. Such conditions lead to improvement soil physical properties including improved infiltration capacity. Benefit from the presence of organic matter in the soil is to reduce the bulk density of the soil so that the soil minerals dissolve. Low bulk density is usually associated with increasing porosity caused by the fractions of organic and inorganic soil. It can be conclude that porosity is parameter that influences the most to absorption coefficient [6]

3.7 Pore size

The result given the size of the Entisol soil pores ranging from 2.859 to 5.493 μm belong to the class of medium-coarse. The soil with more silt content have the more macro pores than the clay soil. Soil with more macro pores will more difficult to retain water that make the plant easy to dry.

The Entisol soil pore size measurement results with SEM test, from Table 6.

Table 6. Data pore size Entisol

Treatment	Pore Size (μm)
K1	4.125
K2	2.859
K3	3.845
K4	4.125
K5	5.070
K6	5.493

3.8 Soil Permeability

Permeability measurement results are presented in Table 7.

Table 7. Results of analysis of soil permeability

Treatment	Permeability (cm/hour)	Criteria
K1	3.81	Average
K2	5.64	Average
K3	4.10	Average
K4	3.17	Average
K5	2.30	Average
K6	1.24	A Bit slow

Soil permeability measurement in a saturated condition shows that the rate of permeability of K1 to K5 has average criteria while K6 criteria are a bit slow. Wherein, the highest permeability rate K2 indicated 5.64 cm/hour and the lowest is K6 which is 1.24 cm/hour. Permeability is affected by the porosity of the soil, Soil pores which initially measurement was macro will be changed to the size of meso because most have been filled with compost. Compost has the same properties as the clay, the more compost, the stronger the bond to nutrients and water, so this is what causes the permeability of the soil with a high content of the compost becomes slower. Soil permeability is also affected by soil thickness, that thicker the soil thickness will increase soil permeability [3]

3.9 Field Moisture Capacity

Measurement results of field capacity moisture content is presented in Table 8.

Table 8. Data on soil moisture field capacity and permanent wilting point

Treatment	2.54 pF(%) (field capacity)	4.2 pF (%) (permanent wilting point)	The water is available(%)
K1	13.16	4.83	8.33
K2	15.03	5.91	9.12
K3	16.40	9.31	7.09
K4	29.62	22.75	6.87
K5	33.09	26.42	6.67
K6	33.25	26.18	7.07

Table 8 shows the test value of 2.54 pF (field capacity). The treatment K1 has the lowest soil moisture content of 13.16% and the highest K6 at 33.25%. In 4.2 pF (permanent wilting point), K1 value is the result of low soil moisture content which is 4.83% and the highest K5 at 26.42%. Ability of soil to hold water in the conditions of field capacity and permanent wilting point with more compost ratio will be higher compared to Entisol soil without compost. There is a close relationship between the increase in organic matter and available water capacity and the ability of soil to survive in drought soil by increasing soil water content with increasing organic carbon.

3.10 Water Available

From Table 8 it can be seen that the highest amount of water available is K2 at 9.12% and the lowest is at 6.67% (K5). From the amount of water available, the highest for Entisol soil is treatment K2, with a big use of compost on the soil compost binding to water the more powerful it in accordance with the nature of the same compost with clay. Humus acts together with clay in retaining nutrients in the form provided to leaching and retain nutrients in a form available to plants and microorganisms. Water available affected of the differences of soil texture and structure which affect field capacity and wilting point because the soil texture and structure determine the content of water soil in certain matrix in retaining water [7]

This suggests that the availability of water for plants on soil with compost improvement will depend on the type of soil and the soil texture. The big difference in soil type and soil texture can affect the suitability of the amount of compost different comparison. In Entisol soil that contains more sand ratio of good compost for water availability is K2 (9 kg mineral soil and 1 kg compost)

4. Conclusion

Entisol soil texture is loamy sand, where soil organic matter, soil thickness, and porosity was increase in each treatment by the increasing of compost using, whereas soil pore size obtain the best size in K6 treatment (5kg soil with 5 kg compost), permeability obtain the best performance in K2 treatment (9 kg soil with 1 kg compost) and water availability obtain the best result in K2 treatment (9 kg soil with 1 kg compost). The availability of water for plants on soil with compost improvement will depend on the type of soil and the soil texture.

Reference

- [1] Tan and Kim H 1986 *Degradation of Soil Minerals by Organic Acid* SSSA Publ. **17** pp 1-25
- [2] Neata G, Teodorescu R, Dinca L and Basaraba 2015 Physico-chemical and microbiological composition of compost from Bucharest municipal waste *Agriculture and Agricultural Science Procedia* pp 486 – 491
- [3] Israelsen O and Hansen V E 1962 *Irrigation Principles and Practices* (New York: Wiley)
- [4] Xin, Zhang J, Zhu A and Zhang C 2015 Effect of long term (23 years) minerals fertilizer and compost application on physical properties of fluvo – aquic soil in the North China plain *Soil and Tillage Research* **156** pp 166 – 172
- [5] Hossain M F, Chen W and Zhang Y 2015 Bulk density of mineral and organic soils in the Canada's arctic and sub – arctic *Information Processing in Agriculture* **2** pp 183 – 190
- [6] Barros J L, O Thiers and F Torres 2015 Feasibility study of estimating the porosity of soils from sounds absorption measurements *Measurement* **77**(2016) pp 213 – 221
- [7] Campos I, Piqueras J G, Carrara A, Villodre J and Calera A 2016 Estimation of total available water in soil layer by integrating actual evapotranspiration data in a remote sensing – driven soil water balance *Journal of Hydrology* **534**(2016) pp 427 - 439