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Effect of Sugarcane Litter Compost on Soil Compaction

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ABSTRACT

Intensive agricultural land use tends to reduce the content of organic matter in soil. Organic content in the soil affects the soil's ability to bind water and the efficiency of fertilizer absorption by plants. It's as well as an important source of nutrients for plants. Therefore, the addition of organic matter in the form of compost (from sugarcane litter) is very important for maintaining the productivity of agricultural land. Use of compost as organic fertilizer on agricultural land is expected to contribute in improving soil structure and increased the production. The aims of the research are to analyze the effect of compost on the physical and mechanical properties of soil and growth of sugarcane (ratoon). The study was conducted on the sugarcane plantations dry land by measuring the physical and mechanical properties of the soil before and after treatment. Parameters measured include: organic matter content, soil moisture content, bulk density and penetration resistance. The data collection of sugarcane growth and soil fertility is done at 4th months old sugarcane (ratoon). The results showed the application of compost increases levels of organic C and N respectively 8% and 21% within 4 months. The use of compost has positive effect on physical and mechanical properties of the soil. It's indicated by bulk density values were decreased (treatment 15 tons/ha of 1:32 g/cc at baseline to 1.1 g/cc at the final of the study). The average growth of sugarcane with compost is better than without the compost on high growth aspect (53.7 cm vs. 51.1 cm) and larger trunk diameter (1.4 cm vs. 1.0 cm).

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Keywords:
Sugarcane litter; compost; sugarcane; physical and mechanical properties of soil

1. Introduction

Modern agricultural activity is characterized by the increased use of agricultural machinery. This is due to the increasing demand for land and food. Mechanization of agriculture by using tractor propulsion has lasted until today. The negative impact of the use of tractors and other mechanical equipment is soil compaction. Soil compaction is a change in circumstances where there is a volume loss of land or an increase in heavy ground at one particular unit volume. Soil conditions or the density of the soil can be determined by certain parameters such as void ratio, porosity, bulk density, and density content (Mandang and Nishimura 1991).

Factors that influence the soil compaction process include heavy tools, tire air pressure, the soil moisture content at the time of passing. In addition, there are other factors to consider is the intensity of traffic tools, wheel slip, and whether new land is pretreated (Hersyami and Sembiring 2000).

Some research indicates that the traffic of tractors in agriculture is one source of soil compaction. Direct influence on the crop that is decreasing the vegetative growth of plants that will ultimately reduce crop production (Stone RJ and Ekwue EI 1993). Hans Kok *et al.* (1996) states that compaction can inhibit plant growth, inhibit the penetration of plant roots, restricting the movement of water and air in the soil and cause the seed to be slow and will eventually be able to reduce plant production.

In addition to producing sugarcane plantation, also has the potential to produce organic fertilizers such as compost derived from organic waste litter cane. Based on research conducted by Toharisman (1991), litter weight of harvested sugar cane on land can reach 20-25 tonnes/ha. In the cultivation of sugar cane produced in addition there are also organic solid waste (OSW) is a very large quantity. Hutasoit and Toharisman (1993) states that when the cane is harvested generated shoots (cane tops) and litter (trash) by the average number of about 20-25 tonnes per hectare. Litter is made up of the wood on the leaves, shoots, and sugarcane are not transported to the factory. Untapped potential by sugar cane plantations in an effort to increase sugar production. It is seen by still doing the burning litter after several days of logging, because litter can interfere with the operation of equipment and machinery at the time of land preparation. Use of compost litter cane as soil amendment and organic fertilizer on farm land is expected to contribute in improving soil physical and mechanical properties as well as increased production of sugarcane.

Compost is an organic fertilizer from the weathering of tissue or plant materials or organic waste. Compost is obtained because no human intervention in the drafting process of creating more micro-conditioned environment for the growth of microorganisms. Compost is the result of the decay of plant debris caused by the activity of microorganisms decomposers. Compost quality is determined by the magnitude of the ratio between carbon and nitrogen ratio (C/N). If C/N is high, meaning the building block of compost has not decomposed completely. Compost materials with a C/N ratio high will break down or decompose longer compared with that of C/N ratio low. Compost quality is considered good if it has a C/N ratio of 10-25 (Permentan 2006).

Based on the results of composting litter sugarcane factory Tasikmadu do in Solo karanganyar obtained compost organic matter content; 1.7% of N, 1.7% of P, 1.91% and 0.3% K element elements Ca (Musnamar, 2003). Physical characteristics of good compost is blackish brown, slightly moist, crumbly, and its constituent materials has not looked back. Dose of use of organic fertilizers are not as strict on artificial fertilizer overdose organic fertilizer will not damage plants, soil, and the environment. The use of certain doses at more oriented compost to improve soil physical and chemical properties than to provide nutrients.

Chemical content varies depending composted materials and weave. For example, at every 10 tonnes of manure will be equivalent to 130 kg N, 330 kg P and 50 kg K, equivalent to 591 kg ZA and 100 kg KCl. If the material was given to the soil will reduce fertilizer costs. Composters on sugarcane plantations would be more easily realized because the technology is available and relatively many raw materials. The purpose of the study are to analyze the effect of sugarcane litter compost on soil physical, mechanical properties and growth of sugarcane ratoon crop.

2. Materials and Method

The research was conducted at the sugarcane plantations of PG. Takalar South Sulawesi, Indonesia. The experimental design is using factors of compost dose with three replications. Dose factor compost consisting of 2 levels ie: K0 (without compost) and K15 (15 tons of compost/ha). Thus there will be 2 x 3 = 6 experimental plots. Once the land was cleared experiment, then made a plot with size of 24 m x 25 m and is divided into 6 plots with each size 4 m x 25 m. Further compost derived from sugarcane litter compost buried beneath the soil surface contained ratoon cane in accordance with the treatment. Measurement of soil physical and mechanical properties performed before treatment and after treatment parameters include: organic matter content, soil water content, bulk density, and penetration resistance. Data collection sugarcane plant growth and soil fertility after a 4 month old ratoon cane.

3. Results and Discussion

Result of analysis shows that the content of organic C and N of the study sites were used only slightly (2.15% and 0.15%). This is indicates that the soil at the study site was classified as less fertile. As the opinion of Singer and Munns (1987) whom states that most of the soil containing organic matter is less than 5% with the majority constituent is carbon (C).

The fields where research is a land with a wavy surface because it is a sugar cane plantation ratoon 3 (R3) that has been harvested, there are still many litter cane and sugar cane stumps that have not must be cut and overgrown with bushes and weeds. Prior to this research, the land is cleared of grass and must be cut with machetes. Land at research sites in PG Takalar a Mediterranean type of land, grumosol, Latosol and Yellow Podzolic. Table 1 shows the content of the elements contained in the soil at the sites.

Table 1. Results of analysis of organic matter at the beginning of the study at PG Takalar

Parameters	The content of the element (%)
C Organic	2.15
N Organic	0.15
C/N ratio	14.33
Sand	18
Silt	20
Clay	62

Soils are composed of organic matter (stuff that used to be alive, like plants and animals) and small inorganic matter. There are three basic soil types: sand, silt, and clay (Elkheir, 2016). The analysis shows a comparison of clay, dust and sand soil is a clay-textured soils based system and has the characteristics USDA will shrink when dry and form a paste when wet. These properties will affect the hardness of the land. Texture clay is a land that has the ability to hold water and provide nutrients high. It is caused by a large area of clay particles (Hardjowigeno 2003). According Soepardi (1983) that the presence of heavy clay, the soil will be processed for pliancy weight if too dry will menggumbal and hard, in the wet state the value of stickiness on the wheels of tractors and earth moving will be higher.

Table 2. Results of analysis of organic matter content at final research in PG Takalar

Parameters	The content of the element (%)
C Organic (%)	2.34
N Organic (%)	0.19
C/N ratio	12.32

The state of the ground before it is processed is level ground and is located in an area that is airy. This situation led to the high value of evaporation and highest evaporation occurs on the surface layer. After the application of compost for 4 months shows that increasing the organic matter content. The result shows that the content of organic C and N, respectively increased the amount of 5% and 21% when compared with organic ingredients at the beginning of the study. Increase the content of organic C and N indicates that the organic fertilizer such as compost effect on the increase in soil organic matter content.

3.1. Compost Effect on Soil Water Content

Table 3. The water content of the soil in PG Takalar

Depth (cm)	The water content on beginning of treatment (%)			
	Compost (K15)	SD	Without compost (K0)	SD
0 – 10	30.97	1.36	23.57	0.17
10 – 20	30.13	0.31	27.35	3.28
20 -30	27.98	0.75	28.66	1.58
	The water content on final of treatment (%)			
0 – 10	39.19	3.40	40.56	1.19
10 – 20	34.06	3.58	37.93	0.25
20 -30	35.67	0.28	35.73	2.24

The percentage of water content at the end of the study when the 5 month old ratoon cane was higher than the percentage of water content in the initial state of the study, is caused by weather conditions, which at the end of the study (November) occurs where the rainy season rainfall intensity is greater than at baseline (month of June) which coincides with the dry season so greatly affect the percentage of soil moisture content in the field.

The measurement results showed that the treatment of organic material such as compost delivery no effect on the percentage of water content. The smallest percentage of water content was 34.06% on compost treatment in 10-20 cm, while the largest percentage of water content was 40.56% on treatment without compost in 0-10 cm. This is happens because at the time of sampling done in the morning at around 7 to 8 o'clock, so that evaporation at the soil surface has not occurred and coincided with the rainy season in the area. Percentage of soil moisture content shows that the crop water requirement is fulfilled and the plant can grow well. Compost in principle can loosen the soil, improve soil structure and porosity, and composition of soil microorganisms, increase the water holding capacity of the soil, keep the soil water longer, and prevents dry patches on the ground.

The water requirement occurs when sugar cane aged 4 to 9 months, which at the age of sugarcane that are in active vegetative period. During this period, the water shortage will impede the growth of sugar cane as a small rod diameter and the distance between the small book so tall tree is reduced. The lowest water requirement occurs when the cane is ready for harvest. When the cane does not need a lot more water, because excess water will affect the cooking process that is causing the yield of sugarcane down. Sugar cane crop given sufficient water in the dry season but the cane does not need to be watered during the rainy season. Estimated water demand for sugarcane crop is 1.5 times the water demand for crops. The total availability of water for crops of sugar cane at the age of 1-12 months, to be between 14.82 mm to 140.5 mm. Such conditions can be achieved when the water content of the soil is at field capacity point.

3.2. Compost Effect on Soil Bulk Density

Bulk density is an indication of the density of the soil. The more dense a higher soil bulk density, which means more and more difficult to pass on water and plant roots to penetrate. In general, the bulk density ranges from 1.1 - 1.6 g/cc. Some types of soil have a bulk density of less than 0.9 g/cc (eg soil Andisol), some even less than 0.1 g/cc (eg peat) (Hardjowigeno, 2003).

The bulk density values before treatment composting to plant sugarcane at baseline ranged from 1.2 g/cc – 1.33 g/cc. Average bulk density values which is highest in the surface soil layer (0-10 cm) is 1.32 g/cc. This is caused by farming activities during the maintenance and care using mechanical equipment and tractor.

During 5 months of maintenance ratoon sugarcane crop has been done 3 times tractor crossings, each one before giving compost application is on interrow, the application of compost, and piling activities. Crops using mechanical equipment and tractors as towing power can loosen the soil in the topsoil but also can cause soil compaction on a particular layer is below the topsoil.

Tabel 4. Bulk density of soil in PG Takalar

Depth (cm)	Bulk density initial condition (g/cc)			
	compost (K15)	SD	Without compost (K0)	SD
0 – 10	1.32	0.01	1.32	0.05
10 – 20	1.21	0.02	1.33	0.08
20 -30	1.24	0.21	1.28	0.13
	Bulk density final condition (g/cc)			
0 – 10	1.1	0.06	1.3	0.07
10 – 20	1.23	0.07	1.2	0.12
20 -30	1.24	0.01	1.33	0.00

The analysis showed that the treatment only affects the provision of compost soil surface layer (0-10 cm) of the bulk density values. In the upper soil layer has the smallest bulk density value is 1.1 g/cc. This is due to compost is given only to a depth of 10 cm. The value of the bulk density will affect the growth of plant roots.

Sugarcane plants have root systems fibers similar to corn. The results of the study Nelson (2012) shows how the effect of soil compaction on root growth of maize seedlings at three different soil bulk density. At the low bulk density of 0.7 g / cm3 shown that plant roots can grow well and decreased growth in the medium bulk density values (1.1 g/cm^3). While on the ground conditions have a high bulk density (1.6 g/cm^3) looks roots of plants experiencing difficulties in its growth. This shows that the soil bulk density values were high (≥1.6 g/cm^3) will inhibit the growth of plant roots that will affect plant growth and can reduce the production of these crops.

Figure 1 shows that the treatment is composting at a depth of 0-10 cm to give effect to the value of bulk density, where the provision of compost 15 tons/ha can reduce the value of the bulk density of 0.22 g/cc, a drop of 16.7%. This is caused by composting only on the depth of 0-10 cm layer. Besides useful for compost plants can also improve soil structure and reduce the effects of soil compaction due of heavy machinery used in the process of raising Sugarcane crops.

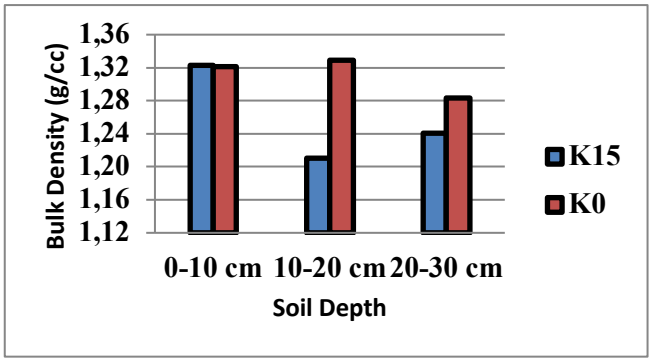

Figure 1. Bulk density before application of compost

Figure 2 shows that the bulk density values at the final of the study in depth of 10-20 cm for treatment without compost decreased when compared with baseline values, this is caused by the development of sugarcane roots at that depth, thereby reducing the density of the soil. In addition to its heavy machinery, bulk density value is also influenced by soil water content in the field at the time when the engine is operating and soil sampling. The tendency of increase in bulk density values along with the many activities the cultivation of plants that use tractor. Soil compaction from tractors trajectory intensity comes from the pressure of the wheel tractor urgent water and air pressure so that the affected areas become more solid and can directly increase the value of soil bulk density, this is in accordance with the stated Harris (1971) that an increase in bulk density values there may be four things happen: (1) compression of solid particles (2) compression of fluid and gas in the pore space (3) changes in the content of liquids and gases in space pore and (4) changes in the composition of the solid particles.

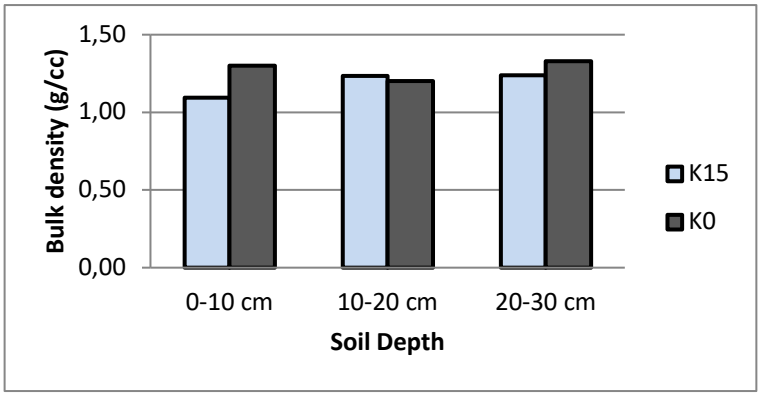

Figure 2. Soil Bulk Density Values After Compost application

The results showed that the treatment effect giving compost (organic fertilizer) can improve soil structure by lowering the value of bulk density and reduce the occurrence of soil compaction due to maintenance activities sugarcane using mechanical equipment and tractors. As the results of research conducted by Charles and Services (2003) that organic fertilizers can improve soil structure and lower bulk density as well as help bind soil particles into aggregates so that the soil is not easily congested by the track wheel. Gill and Berg (1968) states that lowers soil compaction soil aeration thus inhibiting the metabolism of plant roots, increasing the firmness of the ground thus inhibiting the development of roots, decrease soil permeability thereby increasing runoff and erosion. Traffic tools and farm

machinery has contributed to the production plant with soil bulk density value. Added value of soil bulk density can inhibit root penetration into the soil, reducing the availability of air and reduces water infiltration into the soil, thereby reducing crop production (Raghavan 1978 in Lavoie 1991).

3.3. Effect of Compost on Soil Penetration Resistance

The result of penetration resistance measurement (Table 5 and 6) after 4 months old ratoon sugarcane showed that treatment composting influence on penetration resistance. Penetration resistance measurements performed on the same plot with soil bulk density measurements. Penetration resistance measurements performed using penetrometer SR-2.

Table 5. Penetration Resistance on the Final Treatment in PG Takalar.

Treatment	Penetration resistance (kgf/cm²)		
	0-10 cm	10-20 cm	20-30 cm
K15	3.8	7.3	13.2
SD	1.6	0.6	2.8
K0	4.5	10.2	16.7
SD	1.3	3.3	6.1

Table 6. Soil water content on penetration resistance measurement

Treatment	Water content (%) depth (cm)		
	0-10 (cm)	10-20 (cm)	20-30 (cm)
K15	50.4	46.4	41.2
SD	3.6	5.0	4.5
K0	43.2	44.9	44.4
SD	2.8	2.7	3.3

Increasing the value of penetration resistance and bulk density showed an increased density of the soil as a result of increased activity of cultivation using tractors. The activities of the plantation land using tractors of course will affect the value of soil penetration resistance. Figure 3 shows that the value of the greater soil penetration resistance with increasing soil depth. This is caused by the tillage is done only at a depth of 0-10 cm so that the soil on the surface to be loose. Shallow tillage can lead to soil compaction below the topsoil as a result got a compressive force of the tractor wheels causes the ground to experience compression and become solid. Increasing the value of penetration resistance and bulk density showed an increased density of the soil as a result of increased activity of cultivation using tractors. This happens due to compaction of soil particles so that the pore spaces of the soil becomes increasingly narrow or small.

This is consistent with the results of research conducted by Iqbal et al (2006) which states that the trajectory of the tractor wheels can increase penetration resistance and bulk density soil to a depth of 20 cm. Improved soil penetration resistance value is also caused by the percentage of soil water content in the soil at the time of measurement. The percentage of low ground water levels can increase the value of soil penetration resistance. The results of measurements in the field indicate that treatment of compost influence on penetration resistance. It can be seen in Figure 3 where the compost treatment at any depth has a value

of penetration resistance lower than the treatment without compost. This shows that the compost as organic matter can improve soil physical properties and reduce the density of the soil as well as help bind soil particles into aggregates so that the soil is not easily congested by the track wheel (Charles and Services, 2003).

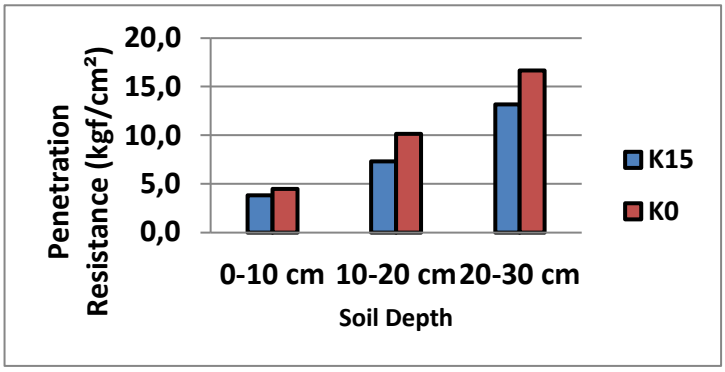

Figure 3. Penetration Resistance (kgf/cm²)

3.4. Performance of Sugarcane Crop

The measurement result of plant height cane shows that the compost treatment plots had an average plant height growth is better than no compost treatment plots. In the compost treatment showed that the average height growth of sugarcane is 53.7 cm per month, while for treatment without compost just experienced an average growth of plant height of 51.1 cm per month. This shows that the compost has a great influence on the growth of Sugarcane. The addition of organic matter such as compost very important role in improving soil fertility due to compost rich organic matter can affect the availability of total-N, available P, available K and produce humic acids that affect the soil CEC.

Table 7. Average monthly growth of sugarcane

Treatment	Sugarcane Performance		Standard Deviation (DS)	
	Stem high (cm)	Stem Diameter (cm)	Stem high	Stem Diameter
Compost	53.7	1.4	9.5	1.6
Without Compost	51.1	1.0	5.6	1.3

Measurement of high-growth sugar cane plant was carried out in the third, fourth and fifth after the application of compost. This was done because the first and second month drought that occurred sugarcane plant growth stunted. In the third start to happen until the fifth month of the rainy season and return to normal plant growth.

Figure 4 shows that there is substantial growth in the fifth on both treatments. Height growth of sugarcane in the compost treatment is better than without compost treatment.

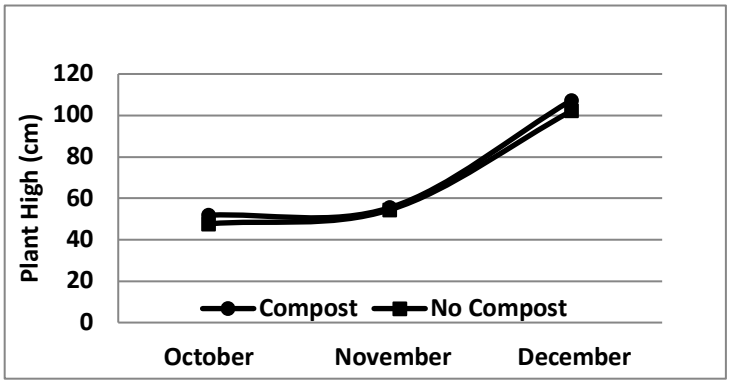

Figure 4. Average Height Growth of Sugarcane

Measurement results stem diameter growth of sugarcane can be seen in Figure 5 shows that an increase in the growth of a large enough diameter in fifth in both treatments. Stem diameter growth of sugarcane in the compost treatment is better than without compost treatment.

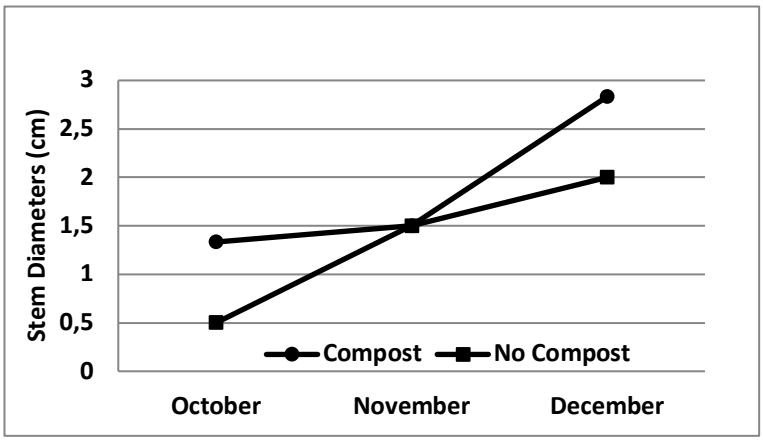

Figure 5. Average Stem Diameter Growth of Sugarcane

The use of compost is very good because it can provide good benefits for the soil and plants. It is according the research by Samad *et al.* (2014), treatment a combination organic (compost) and an-organic fertilizer increase the plant production. Compost can loosen the soil, improve soil structure and porosity, and composition of soil microorganisms, increase the water holding capacity of the soil, groundwater store longer, and avoid dry patches on the ground. Compost also provides macro and micro nutrients for plants, facilitate the growth of plant roots, preventing some root diseases, and can save the use of chemical fertilizers or artificial fertilizers, thus increasing the efficiency of use of chemical fertilizers.

4. Conclusion

After application organic fertilizer made the content of organic C and N, respectively increased the amount of 5% and 21% when compared with organic ingredients at the beginning of the study. The treatment of organic material as compost no effect on the percentage of water content. Treatment effect giving compost (organic fertilizer) can improve soil structure by lowering the value of bulk density and reduce the occurrence of soil compaction. Besides, the compost treatment at any depth has a value of penetration resistance lower than the treatment without compost. The average growth of the ratoon sugarcane crop with compost is better than without compost of the high growth and stem diameter aspects.

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