ROLE OF *Gliricidia sepium* IN IMPROVING AGGREGATE STABILITY OF ULTISOL LIMAU MANIS PADANG: A LABORATORY STUDY

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Abstract

There is no much public concern about soil aggregate stability improvement of a soil. This is due to the fact that it does not directly affect crop yield for a short term, but it determines sustainable agriculture and development for a long term. This research was aimed to investigate soil physical properties especially soil aggregate stability of Ultisols after fresh OM application, then to determine the exact OM dosage to improve the stability. Ultisols used was from Limau Manis (± 367 m asl), an area in lower footslope of Mount Gadut, having wet tropical rainforest. Due to land use change, farming activities in that sloping area could enhance erosion process in the environment. Therefore, efforts to anticipate the erosion must be found. Fresh OM applied was *Gliricidia sepium* which was found plenty in the area. Five levels of fresh *Gliricidia sepium*, were 0, 5, 10, 15, and 20 t/ha. Top soil (0-20 cm depth) was mixed with OM, then incubated for 3 months in glasshouse. The results after a 3-month incubation showed that SOM content did not statistically increase, but it improved based on the criteria, from very low to low level as OM was applied for ≥ 10 t/ha. It seemed that 10 t/ha Gliricidia sepium was the best dosage at this condition. There was a positive correlation between SOM content and aggregate stability index of Ultisols after fresh Gliricidia sepium addition.

Keywords: *Ultisols, soil aggregate stability, soil organic matter content*

INTRODUCTION

Rapid change of land use in Indonesia lately has moved crop farming into marginal soil. One of marginal soil found in West Sumatra is Ultisols, covering an area approximately 45.8 million ha or 24.3% of Indonesian terrestrial (Hakim, 2006). It has low productivity due to its poor chemical and physical properties. In West Sumatra, especially in Limau Manis the soil is classified into sub ordo Udult and sub group Orthoxic Tropoudults (Imbang *et al.*, 1994). This soil does not only have bad chemical properties but also also has unprofitable physical characteristics (Hakim, 2006). The soil is not suitable for annual crops due to its physical properties and topography condition, but it is still used by farmers for seasonal crop farming with intensive cultivation. This kind of activities accelerated SOM oxidation and finally aggregate degradation (Yulnafatmawita, 2006).

Stabilizing soil aggregates as well as keeping the pore size well distributed was very important to increase infiltration and permeability rate into soil in order to anticipate runoff on soil surface which leads to erosion. Additionally, balanced quantity between water and air within soils will optimize microorganism activities and maximize nutrient availability as well as its absorption by crops. One way to reach stabile soil aggregates was trhough increasing SOM content, since OM plays a significant role in creating and stabilizing soil aggregates. As reported by Annabi *et al.* (2007) that compost could increase soil aggregate stability by increasing cohesion among soil particles due to organic substance diffusion into soil aggregates.

Aggregates created by OM binding agent are quite stabile against input energy impact and promptly soil wetting. This is due to the properties of OM which cannot be dissolved in water as other binding agent, like clay, and many others. That is really important for farming land in wet tropical and sloping areas, such in West Sumatra, to anticipate soil structure degradation which finally ends with natural disaster, such as erosion, land slide, flood during rainy and lack of water during dry season.

However, SOM content in tropical soils is used to be low due to high temperature and soil moisture enhancing SOM decomposition. In addition, management given to a piece of land will also affect SOM degradation. Soil OM decomposition rate will be accelerated if the OM is more exposed to the atmosphere, such as due to tillage practice. Soil cultivation causes the SOM become easier to reach by decomposers. As reported by Yulnafatmawita *et al*. (2003) that SOM would be oxidized faster under more than less tillage intensity. Furthermore, she explained that land use change from rainforest into grassland for approximately 100 years in sub-tropical region decreased org-C Ferrosol from 6.9 to 5.6% (Yulnafatmawita, 2004).

Intensive soil cultivation is used to practice for preparing seasonal farming system, especially for grain and vegetable crops. Farmers, in West Sumatra, still consider that the best way to prepare land for farming is by cultivating soils as intensive as possible until the aggregates are fine and the soil becomes porous, without any weeds and crop residues left on the farmland. Returning crop residues after harvesting does not yet become habit by our farmers, they just remove it from farmland and burn it, instead.

Soil OM oxidation rate in West Sumatra, such as in Padang is quite high. Yulnafatmawita (2006) found that SOM content of Ultisol Limau Manis decreased by 55% (from 9.86% to 4.42%) at 0-10 cm and 18% (from 3.79% to 3.10%) at 10-20 cm depth as land use change from forest ecosystem into seasonal farming system after approximately 10 years.

Theoritically, based on its climate and topography, the land was not suitable anymore for annual crops, but it is still cultivated by people to grow food crops for their life. This kind of farming practice has caused erosion if it is rain. This can be proved by differences of river current as well as the water color between under rain and no rain.

In order to anticipate the greater disasters as well as to keep sustainable land productivity, improvement of soil physical properties, for example stabilizing soil aggregates, is a must. One way to reach the objective is by increasing SOM content. Sources of OM could be from manure, compost, green manure, organic waste, and many others. Fresh organic matter derived from vegetations grown in the farming land will give several advantageous. The most important thing is that it does not need transportation cost and it can be used as needed. Then, it can also planted as a fence for farming land. Among types fresh OM source used was *Gliricidia sepium*. This plant are known as a type of green manure, because it can contribute some nutrients for plant growth. Jamilah (2006) has used gliricidia for corn, soybean, rice and other seasonal crops. Gusnidar et al (1994) reported that plant could survive in acid soils, and quite responded to liming. Based on the above facts, this research was conducted to identify soil physical properties of Ultisols after OM application, then to determine the best OM source and the dosage to improve the aggregate stability of Ultisol. The results are hoped to provide data in founding conservation technology for hilly and marginal land cultivated for seasonal crops under super wet tropical areas.

MATERIALS AND METHODS

This research was conducted as laboratory experiment in 2008. The work was started by sampling soil in the field, for pot trial as well as for initial soil physical analyses. Soil samples were brought to laboratory, dried, ground (except for aggregate stability analyses) and sieved using 2 mm for pot trials and soil texture analysis, and 0.5 mm for other soil physical characteristics analyses. Initial soil properties analyzed were soil texture (pipette and sieve method), BD and total pore (gravimetric method), permeability (constant head based on Darcy's law), OM content (Walkley and Black method), soil pore distribution (filter paper method), percentage of soil aggregation (Dry sieving method), and aggregate stability index (Dry and Wet sieving method). The green part of *Gliricidia sepium* was cut about 4 cm in length, then mixed with soil. The experiment consisted of 5 levels of OM dosage (0 t/ha, 5 t/ha, 10 t/ha, 15 t/ha, and 20 t/ha) with 4 replications. The experimental units were allocated as completely randomized design in glasshouse. The soils were watered and kept around field capacity, and led them stay for 3 months. After a 3-month incubation, soils were sampled for SOM content and aggregate stability analyses.

RESULTS AND DISCUSSION

Initial Soil Physical Properties

Initial soil physical properties of Ultisol Limau Manis are presented in Table 1. As described in Table 1, Ultisol Limau Manis, in general, had low soil physical fertility. It was shown by high clay content and very low SOM content, low aerated pores, and slow permeability rate. Low SOM had caused the soil aggregates became unstable. This condition of soil will be easily degraded if it is intensively cultivated for annual crop farming. Low soil macropres (aerated pores) could influence water transmission in the soil, therefore, soil will slowly absorb water from the soil surface (low infiltration rate) during rain or irrigation. As Limau Manis area has very high annual rainfall, the water will flow out on soil surface into lower area bringing soil particles and the soil solution, due to the wavy and hilly topography. Erosion has started so far in Padang city. This could be proved through different river water color as well as the current (debit) between during and no rain.

Big natural disaster as happenend in many areas in Indonesia lately could also happened, if it is not anticipated since now. Flood during rainy season and drought during dry season are parts of the impact. In fact, if it rains for consecutive 3 days, Padang will be flooded, even though it can be drained on the following day.

Tabel 1. Initial physical properties of Ultisol Limau Manis

Parameter	Value	Criteria
Particle size distribution		
- Sand (%)	20,21	
- Silt (%)	12,18	
- Clay (%)	67,61	
Texture class		Clay*)
Permeability (cm/h)	0,37	Slow**)
BV (g/cm^3)	1,03	Medium**)
TRP (%)	60,54	Medium **)
Aerated Pores (% volume)	5,50	Low**)
Slow Drain Pores (% volume)	12,58	Medium **)
Available Water Pores (PAW) (% volume)	11,32	Medium **)
SOM (%)	1,62	Very Low**)
Aggr. Stability Index	39,93	Unstable**)

Source: *) *Diagram segitiga tekstur menurut USDA*
**) *Lembaga Penelitian Tanah (LPT) Bogor (1979)*

Soil OM content and Aggregate Stability Index

Tabel 2. Soil OM content, percent aggregation, and aggregate stability index of Ultisol Limau Manis after *Gliricidia sepium* application for 3 month under laboratory condition.

OM Level (t/ha)	Organic Matter (%)	Aggregation (%)	Aggregate Stability Index
10	2.12 a* (L)**	67.14 a	47.55 a (LS)
15	2.08 a (L)	65.21 a	46.78 a (LS)
20	2.05 a (L)	64.25 a	46.65 a (LS)
5	1.99 a (VL)	62.43 a	44.58 a (LS)
0	1.84 a (VL)	58.99 a	43.33 a (LS)
CV (%)	21.41	9.70	12.06

**) Statistical analyses. Numbers followed by small words on the right row are not significantly different based on F-test at 5% level. **) Criteria based on LPT Bogor (1979. VL = very low, L = low, LS = less stable*

High clay content was due to intensive weathering happening in this area, since the area has very high annual rainfall as well as high temperature (wet tropical rain forest). Annual rainfal in this area was found to be around 4500 mm, and up to 6500 mm in the upper footslope of Mount Gadut (Rasyidin, 1994). Water is the most important factor in chemical weathering, because it can cause hydration, reduction, solubilizing, and other chemical reaction. Then, water will leach some soluble cations in soils, causing the soil become poor in chemical properties, such as low pH and plant nutriens (Hakim, 2006).

High kinetic energy of rainfall could detach soil aggregates, disperse the particles, and finally moved them to lower soil horizon or to lower area as erosion. Therefore, the soil was considered as advanced weathering or old.

After being statistically analyzed the data, it was found that there was no significant difference either organic matter, aggregation, or aggregate stability index among the treatments given. This could be due to the time given to incubate *Gliricidia sepium* within soil was not enough for microorganisms to degrade the OM added yet. However, there was a tendency of increasing OM content, aggregation percentage, as well as aggregate stability indexes as OM dosage increased from 0 to 10 t/ha Then, they tended to decrease as OM addition further was increased until 20 t/ha. It was believed that if incubation was led a little bit longer, the OM could be more decomposed.

At level >10 t/ha *Gliricidia sepium* added, it seemed that the portion of OM was too much in the soil, therefore, the microorganisms did not intensively degrade the materials. As known that, microorganisms will actively work if the energy source for their life is limited, and vice versa. At this time, the optimum level of fresh *G. sepium* needed was found to be 10 t/ha for a 3-months incubation. However, that amount of fresh OM was not able to statistically increase SOM, %-aggregation, as well as aggregate stability index of Ultisol Limau Manis under controlled condition.

Therefore, it needed more than 3 months for incubation before it could fully contributed to improve SOM contentand aggregate stability.

Index of aggregate stability of Ultisols was found to be affected by SOM content. As described in Figure 1 that, there was a positively linear correlation (R^2 =0.97) between SOM content and index of aggregate stability of Ultisols. It means that 97% of aggregate stability index of Ultisols Limau Manis was affected by SOM.

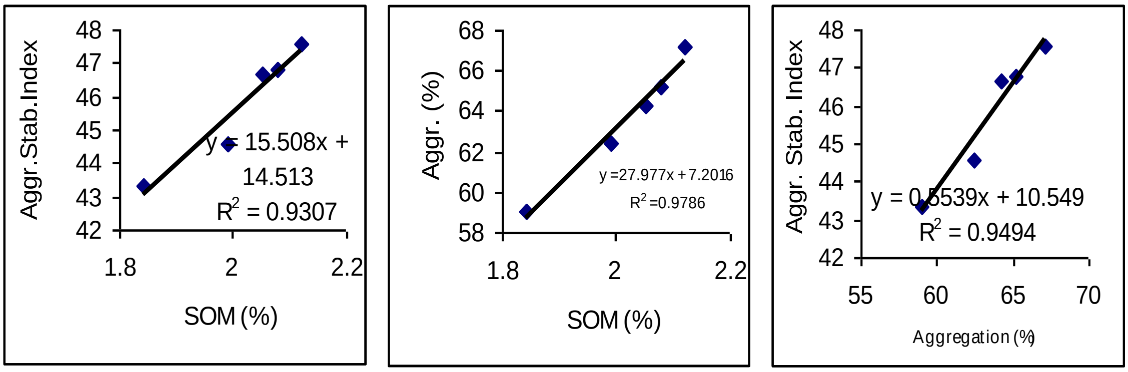

Figure 1. Relationship between SOM content and aggregate stability index as well as Aggregation Percentage, and the relationship between Aggregation Percentage and Aggregate Stability Index of Ultisols

Figure 1 was also showed a linear relationship between SOM content and percent aggregation. It was found that about 98% of aggregation process was due to SOM. SOM content. Then, aggregation percentage was also found to be linearly correlated with aggregate stability index

From the figure1, it can be concluded that SOM functioned well in the process of aggregation as well as the stabilization of aggregates of Ultisol Limau Manis

CONCLUSION

Based on the research, application of fresh OM (*Gliricidia sepium*) up to 20 t/ha to Ultisol Limau Manis after 3 months, it could be concluded that,

1. There was not enough time to significantly improve soil aggregate stability as well as SOM content
2. However, there was a tendency of increasing SOM content, percentage of soil aggregation, as well as aggregate stability index.
3. There was a positive correlation between SOM content and soil aggregate stability index
4. Application of 10 t /ha *Gliricidia sepium* gave highest result

Suggestion

Application of Gliricidia sepium in fresh form needs more than 3 months before it improves soil aggregate stability index as well as SOM content.

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