



## **The Effect of Soil Slope and Organic Materials on Changes of Land Physical Properties and Napier Grass (*Pennisetum purpureum*) Production**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The movement of water and organic material in the hill slope area influenced by the difference of soil slope and it play an important role to contribute the spatial differences of soil properties. Therefore, this study aims to examine changes in parameters of soil physical properties on various slopes due to the provision of types of organic matter (manure, coffee skins and *Gliricidia* leaves). This study also analys the influence of slope soil to the Napier grass production (*Pennisetum purpureum*). The study was obtained in the hilly areas of Paya Tumpi Village by using a *split plot organic design*. In deep analysis of change in parameters on the slope of the type of organic material on soil physics will be performed. The results showed that organic various types of slope and administration of various types of organic materials significantly affected the physical properties of the soil, namely permeability, porosity, aggregate stability index, fast drainage pore, slow drainage pore, available water pore, growth and yield of Napier grass. *Gliricidia* leaves compost is the best for growing Napier grass.

**Keywords:** *Soil physics properties; napier grass; organic materials; soil slopes.*

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## 1. INTRODUCTION

Plant growth and cultivation are highly depending on soil fertility condition [1], the most is physical properties of the soil itself, since it needs sufficient air and water besides nutrients [2]. Based on Edaphology, soil physical properties play important role in determining plants growth and development [3]. In addition, [4] explained that the physical properties of the soil greatly affect other properties in terms of its ability to support plant life. Soil ability to store water deeply relates to the function of soil texture and structure. Soil ability to hold nutrients and to make it available for plants is determined by the soil and clay minerals.

By maintaining high quality soil aggregate, the soil properties difficult to be dispersed and contains high porosity, as a result water infiltration into the soil increase constantly, reduce surface flow and soil erosion. Reducing surface flow and soil erosion, mulch residue, in addition, also improve the soil ability to hold water, reduce power of root penetration, stabilize soil aggregates, improve soil aeration, and control drastic temperature fluctuation between day and night so it has no adversely affect to the plants growth [5]. The more stable soil aggregates, the more soil resist from rain blows. In addition, the increasing of water infiltration capacity will have an impact on reducing surface flow, thus erosion can be reduced as well [6].

In deep assessing relation with soil and geomorphic surface was performance by many research in a decade such as nitrogen concentration, carbonate, organic carbon and thickness of the epipedons, and exchangeable magnesium were significantly different on various slope positions [7]. The soil properties and an organic material on different slope positions were also studied and concluded which soils in foot slope and toe slope are contained higher organic carbon and aggregate stability than summit soils [8]. Chen et al. [9] have report that slope position can alter soil nutrient availability since of higher concentration of Fe, Mn, Cu and Zn in the upper slope soil positions. Venterea et al. [10] observed the patterns of  $\text{NO}_3$  concentration and net nitrification rate associated with physiographic features. The result shows that greater rates of net  $\text{NO}_3$  production, Nitrogen mineralization rates, and total N concentrations were associated with higher plot elevation.

According to Arsyad [11], tilt or steepness of the slope is denoted in degrees or percent. Steepness of the slope will increase surface flow, thus increase the soil haulage capacity. An organic material is also the important think in order to growth the soil fertility, especially on dry land slope, Organic material able to decrease soil erosion rate by improving soil physical structure. The soil needs at least 2% of material organic in the upper layers to conduct an optimal condition for plant growth necessity. In addition, additional fertilizer is needed, especially on soil surfaces that have an organic content of less than 1 percent [12].

By Endriani [13], the fertilization using forage organic matter as much as 20 tons  $\text{ha}^{-1}$  able to reduce soil bulk density to the tune of 6.25 percent, increase 3.6 percent of the total pore space, increase the water pore availability at 2.92 percent and increase the total formed aggregates in 48.27 percent compared with no organic material at all. It can be inferred the important of organic matter in the fertilization. Napier grass (*Pennisetum purpureum*) is an excellent grass with high productivity and nutrient. The perennial grass wich is widely planted as fodder crops and feed for a zero-grazing dairy product system [14] and very beneficial for small dairy farms up to 80% [15]. Therefore, this forage became to the world wide choice for fodder crops [16] since of its desirable traits such as efficiency water consuming, high photosynthetic, tolerance to drought and its strength for wide range of soil properties [17].

## 2. RESEARCH METHODS

The research was carried out at hill site of Central Aceh Regency, on 1300 m altitude above sea level (masl) and also soil pH was measured at 7.0 soil pH. Research area with a high rainfall level, and an average temperature below 25 degrees Celsius. Coffee is the main commodity in this region, in addition to that there are also several fast-harvest crops such as chili, onions and potatoes. Inceptisol soil type with dusty clay texture. Before being used for research, the field as shown by Picture 2 was left abandoned by farmers so that weeds were overgrown. The design will be used in the research is factorial pattern Split Plot Design (Hanafi, 2010 b). There were two factors which were attempted, the first factor was Main Plot include 3 levels, there are: (1) the slopes of 8-12% (L1), (2) the slopes of 12-16% (L2), and the slopes of 16-20% (L3). The

second factor (sub-plot) consists of three types of organic materials, there are: (1) coffee bean skin (B1), (2) cattle manure (B2), and (3) *Gliricidia* leaves (B3) as shown by picture 4.



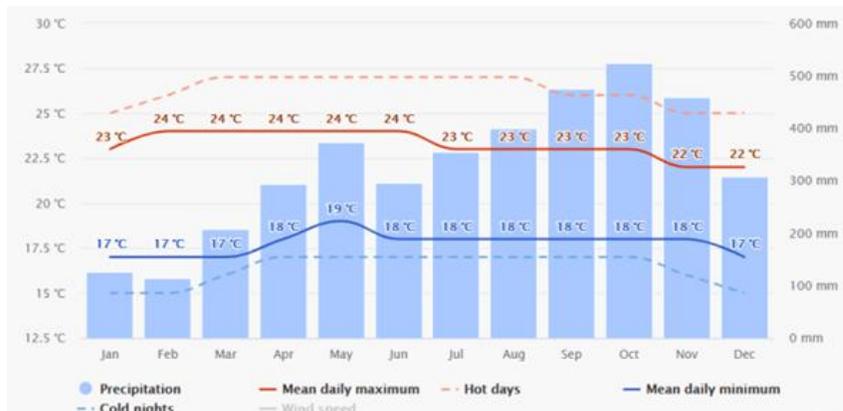
Picture 1. Satalite view of research field (Google Satalite)



Picture 2a. Research location before treatment



Picture 2b. Research location after treatment



Picture 3. Average temperature and prepicition in middle aceh in a year



**Picture 4. Three type of organic material for soil properties**

Thus, the observation obtained a few treatments combinations, which is each repeated three times, in last obtained 27 units of research. The implementation of the research included: seed and several kind of organic material preparation, land preparation, coffee bean skin, cattle manure and *Gliricidia* leaves distribution, plantation and maintenance. Parameters of observation included soil physics, pre-planting, elephant grass (*Pennisetum purpureum*) height, and production of Napier grass (*Pennisetum purpureum*)

### 3. RESULTS AND DISCUSSION

#### 3.1 Organic Ingredients

The analysis showed there were differences nutrient content of eac compost. *Gliricidia* leaves content water as much as 14.16% and cattle manure 9.64%. Coffee bean skin compost composition pH 7.24, *Gliricidia* leaves reached pH 6.86 and cattle manure 6.48%. The total N content, C organic, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O in the coffee bean skin compost and *Gliricidia* leaves are higher than cattle manure. The content of C/N, C<sub>a</sub>O and M<sub>9</sub>O of *Gliricidia* leaves and cattle manure compost are higher than coffee bean skin compost.

#### 3.2 Experiment Location Characteristics

The analysis result of soil physics research area before the experiment was shown as Table 1.

#### 3.3 The Effect of Organic Matter on Soil Physic

Results of variant analysis showed that the organic matter has significant effect on soil physic as presented in Table 2. Table 2 showed that soil weight volume reduce directly due to the providing of all organic matter. Providing tested organic matter with various types increased soil

porosity, coffee bean skin distributing contributed a significant differences compare with cattle manure and *Gliricidia* leaves. The result also shows there were not significant porosity value beetwen coffee bean skin and cattle mature. Provision of various types of organic materials able to raise the value of soil porosity, organic matter such as coffee bean skin and cattle manure were not significantly different, but both are significantly different from the type of organic material such as *Gliricidia* leaves. Providing the type of organic material able to raise the aggregate stability index, rapid drainage pore, slow drainage pore and pore water availability.

Table 2 shows the significant soil physic agregate form the organics materials, the result shows a differences result between coffee bean skin with cattle manure and *Gliricidia* leaves. This occurs due to the function of organic material in fixing soil properties. In accordance with Intara et al. [18], by providing organic matter, it can increase the water availability in the soil, therefore able to reduce the amount of evaporation and increasing the soil water depository, thus reducing the rate of evaporation that occurs in the soil.

#### 3.4 The Effect of Organic Materials to Napier Grass Height

The analysis result from variant experiment showed that providing type of organic material contributed significant effect on Napier grass height as presented in Table 3.

Table 3 showed that the first (I) cutting, provision of cattle manure was different with *Gliricidia* leaves compost. It was not quite different with coffee bean skin compost. Meanwhile, on cutting II the provision of coffee bean skin compost and cattle manure were not significantly different, but both were significantly different with organic materials such *Gliricidia* leaves. On cutting III,

**Table 1. Soil physics analysis in the experiment field before treatment**

Slope (%)	WV (g cm <sup>-3</sup> )	Permeability (cm hour <sup>-1</sup> )	Porosity (%)	Agg. stability index	Pore distribution		
					RDP (%)	SDP (%)	WPA (%)
(East) 8-12	1,18	2,83	50,74	45,64	7,14	5,22	8,70
(North) 12-16	1,16	2,83	50,74	47,36	6,82	7,84	7,64
(West) 16-20	1,15	5,96	52,36	49,84	7,59	9,05	11,34

**Table 2. Average soil physic due to provision of organic matter**

Organic materials (ton/ha)	Permeability (cm hour <sup>-1</sup> )	Porosity (%)	Aggregate stability index	Pore distribution		
				RDP (%)	SDP (%)	WPA (%)
Coffee Bean Skin	4,97a	54,0a	36,81a	6,96a	4,08a	10,20a
Cattle Manure	7,10b	59,0a	55,10 b	11,15b	6,69b	13,54b
<i>Gliricidia</i> Leaves	8,29b	64,3b	58,93b	13,50b	8,87b	18,51b
BNT <sub>(0,05)</sub>	4,66	32,47	27,87	4,56	3,49	7,52

Note: Figures followed by the same letter in the same column are not significantly different at the BNT tested rate of 5% HV: Heavy Volume, RDP: Rapid Drainage Pore, SDP: Slow Drainage Pore, WPA: Water Pore Availability

**Table 3. The average height of napier grass stem on cutting I, II and III**

Organic materials	Napier grass height		
	Cutting I (cm)	Cutting II (cm)	Cutting III (cm)
Coffee Bean Skin	37,57 a	58,33 a	72,39 a
Cattle Manure	52,67 b	59,39 a	81,68 b
<i>Gliricidia</i> Leaves	56,83 b	65,87 b	91,39 b
BNT 0,05 %	13,71	36,47	39,81

Note: Figures followed by the same letter in the same column are not significantly different at the BNT tested rate of 5%

the providing of each organic materials was significantly different each other. The highest value obtained in *Gliricidia* leaves on each cutting age. This was because organic matter can provide nutrients for the grass, so that the plant nutrients are sufficiently fulfilled. Ako [19] was explained that the rate of plant growth on Napier grass increased along with age of the plant itself and the level of fertilizer application. The process weathering of organic matter and absorption capacity plants to organic material affected the growth of plants. Moreover, it also caused by physical structure and condition. The ability of soil physical

condition is also influenced by several supporting substances derived from the provision of organic material.

### 3.5 The Effect of Organic Materials to Napier Grass Production

Further analysis of organic material to Napier grass production also showed that the organic material provision has significant effect on the production of Napier grass on the cutting III as presented in Table 4. The table shows the effect of organic material to Napier grass production weight.

**Table 4. Average production of napier grass on cutting I, II and III**

Organic materials	Elephant grass height (kg ha <sup>-1</sup> )		
	Cutting I	Cutting II	Cutting III
Coffee Bean Skin	0,22	0,66	0,69 a
Cattle Manure	0,47	1,18	1,61 b
<i>Gliricidia</i> Leaves	0,62	1,42	1,97 b
BNT 0,05 %	-	-	0,37

Note: Figures followed by the same letter in the same column are not significantly different at the BNT tested rate of 5%

Table 4 showed that providing organic matter able to increase the production of Napier grass cutting age. In cutting I, provision of coffee bean skin was different with cattle manure and *Gliricidia* leaves compost. In cutting II each treatment combination between coffee bean skin and cattle manure were not significantly different. However, both of them were significant different with *Gliricidia* leaves compost. In can be inferred that by improving the cutting treatment and providing organic materials it will increase the grass growth. Therefore, it can curb the organic rate of nutrients carried by water.

Cutting III indicated significantly differentiation between the distribution of coffee bean skin and cattle manure or *Gliricidia* leaves as well, but the last two were not significantly different. It was since the nutrients in the organic material had been absorbed by the grass, thus the growth of the grass would get better. Cattle manure and other organic material can enrich the soil nutritional elements, improve soil organic matter content, and refresh the plant growth environment that is able to increase the production of other crop.

Priangga's research results explained that nutrient content greatly affected the production of wet / dry material of Napier grass. Provision of types of organic material will be very beneficial for nutrient content in the soil. If the nutrient content is met in the soil, it will increase Napier grass production. Meanwhile, Napier grass production will decrease if there is limited organic

content in the soil [20]. Furthermore, By providing organic material will increase the holding capacity of water, so that the soil will be able to hold more water. Thus, ground water is useful for plants and soil fertility and the plant roots easily absorb food substances for their growth and development.

### 3.6 The Effect of Slope

#### 3.6.1 The effect of slope to the soil physics

The ground slope influence on the content of the elements in the ground has been analyzed. The result shows that the soil slope give a significant contributed on soil physic aggregates. Table 5 showed that weight volume (WV) reduction occurred due to the influence of each gradient. The slope of 12-16%, 8-12 %, and 16-20% was not significantly different. The slope indicated the reduction value of WV (weight Volume) on three types of slopes after the organic material was provided. Regarding this matter, deep research has been done for the result, such as Endriani [13]. The research inferred the higher organic matter contents will reduce the WV soil value.

Reduction of permeability, porosity, aggregate stability, and slope pore distribution of the soil slope was occur as shown in Table 6. The slope 8-12% and 12-16% were not significantly different, but they were significantly affect the slope of 16-20%. It was assumed that the steeper slope the lower permeability and porosity were.

**Table 5. The influence of slope for soil weight weight volume (WV)**

Slope (%)	WV (g cm <sup>-3</sup> ) Before experiment	WV (g cm <sup>-3</sup> ) after experiment
8-12	1,18	1,10
12-16	1,16	0,72
16-20	1,15	1,10

**Table 6. Average soil physic due to the slope**

Slope (%)	WV (g cm <sup>-3</sup> )	Permeability (cm hour <sup>-1</sup> )	Porosity (%)	Aggregate stability index	Pore distribution		
					RDP (%)	SDP (%)	WPA (%)
8 - 12	1,10b	6,54a	58,42a	55,55b	10,75b	6,54b	15,74
12 - 16	0,72a	6,65a	58,34a	37,28a	8,39a	5,01a	9,48a
16 - 20	1,10b	7,17b	60,65b	58,01b	12,47b	8,09b	17,03b
BNT <sub>(0,05)</sub>	0,55	3,80	3,63	27,87	9,10	2,27	6,66

Note: Figures followed by the same letter in the same column are not significantly different at the BNT tested rate of 5%

RDP: Rapid Drainage Pore , SDP : Slow Drainage Pore, WPA: Water Pore Availability

The Effect of slope to the pore distribution showed the lowest steeper slope rapid drainage pore and water pore availability were. Appropriate with Endriani [13] researchs, the steeper land soil structure formation process was not running properly due to natural disturbances such as soil erosion. Eroded soils were more solid and lack organic matter, therefore the formation of the structure was not going well. More organic matter and nutrients loss from the Napier grass plant around the steeper slope area. It since of surface flow in terms of flowing water velocity, the surface flow velocity on the steep slope would increase larger haulage capacity of the soil grains, thus the amount of eroded soil enhance.

**3.6.2 The effect of slope to the napier grass height**

The experiment result shows the affected of slope to Napier grass height. The result showed that the slope significantly affected the Napier grass height as presented in Table 7.

**Table 7. Average height of napier grass during mowing I, II and III**

Slope (%)	Napier grass height (cm)		
	Cutting I	Cutting II	Cutting III
8-12	59,16 b	72,05 b	98,94 b
12-16	36,62 a	58,08 a	73,12 a
16-20	51,28 b	53,46 a	73,39 a
BNT 0,05%	32,33	27,17	36,91

*Note: Figures followed by the same letter in the same column are not significantly different at the BNT tested rate of 5%*

Table 7 shows that grass height was lowest on slopes with 16-20%. The difference in the steepness becomes the cause of the phenomenon, this affected by the level of nutrient content in the soil. each slope would increase surface flow, which would increase the haulage capacity of water. The higher the step of slope will reduce the soil's ability to hold organic matter nutrients carried by water. Thus, the additional organic matter becomes an important thing to increase the growth of plants in this slope region. According to Arsyad [11] and Stevenson [6], adding the organic fertilizer had an important role on sloping land, its impact in decreasing the rate of soil erosion and also able to reduce the loss of nutrients in the soil. Therefore, it provided a good plant growth

**3.6.3 The influence of slope on napier grass production**

Results of variant analysis showed that the slope also significantly affected the production of Napier grass in the cutting II and III as presented in Table 8.

**Table 8. Average production of fresh napier grass on cutting I, II and III due to the slope**

Slope (%)	Napier grass production (kg <sup>ha</sup> <sup>-1</sup> )		
	Cutting I	Cutting II	Cutting III
8-12	0,62	1,64 b	2,02 b
12-16	0,36	0,91a	1,22 b
16-20	0,32	0,71a	1,02 a
BNT 0,05%	-	1,48	1,74

*Note: Figures followed by the same letter in the same column are not significantly different at the BNT tested rate*

Table 8 showed the differences of Napier grass production between cutting I and cutting II and III. The result was significantly different during cutting II and III. Differences of soil nutrient also considered become a problem. Nutrient loss on slopes 8-12% is quite low, so the Napier grass production increased. In the slope 16-20%, nutrient loss is quite high, thus the production of Napier grass reduced. the negative effect that occurred in erosion area were productivity deterioration, loss of nutrients, crop quality deterioration, enhancement of infiltration and reduced the soil ability to retain water, as the result the soil becomes damaged.

The role of other organic materials, which had important practical significance, especially on dry land slope, was its impact to decrease the rate of soil erosion. It occurred by the improvement of soil structure which provided more soil aggregation, thus caused soil resistance against rain blows. In addition, by the enhancement water infiltration capacity would have an impact on reducing surface flow so that erosion could be reduced as well. Added that the steeper or longer the slopes was the more amount of erosion was, if the slope was steeper than the surface flow velocity increased so that the haulage capacity was also increased .

**4. CONCLUSION**

The analysis of soil slope effect and organic materials on changes in land physical properties and Napier grass (pennisetum purpureum)

production has been performed. The result shows various types of slope and supports various types of organic matter are related to soil volume weight, permeability, porosity, aggregate stability index, fast drainage pore, fast drainage pore, available air pore, growth and yield of grass, available on heavy soil volume. The result shows the slopes soil influences the Napier grass production. The research indicated the highest Napier grass production in the first slope area (8-12%) and the lowest addition organic material also. Since of the soil's ability to keep the soil nutrient. It can be inferred level of slope inversely proportional to the soil's ability to keep organic material. The research also inferred Gliricidia Leaves was the best organic materials to be used in order to improve the soil physics and the growth of Napier grass on slopes 16-20%.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

- Andrews SS, karlen DL, mitchell JP. A comparison of soil quality indexing methods for vegetable production systems in northern california. *Agric. Ecosyst. Environ.* 2002;90(1):25–45.
- bünemann EK, et al. Soil quality – A critical review. *Soil Biol. Biochem.* 2018;120(2): 105–125.
- Pal DK, Wani SP, Sahrawat KL. Vertisols of tropical Indian environments: Pedology and edaphology. *Geoderma.* 2012;189–190:28–49.
- Moghimian N, Jalali SG, Kooch Y, Rey A. Downed logs improve soil properties in old-growth temperate forests of Northern Iran. *Pedosphere.* 2020;30(3):378–389.
- Alibasyah MR. Perubahan beberapa sifat fisika tanah, tingkat erosi dan hasil jagung pada ultisol dengan tiga sistem olah tanah dan mulsa jagung serta EFEK residunya. Disertasi. *Progr. Pascasarj. Univ. Padjadjaran.* Bandung; 2000.
- Stevenson FJ. *Humus chemistry: Genesis, composition, reactions*, 2nd edition. 1994; 2.
- Rezaei H, Jafarzadeh AA, Alijanpour A, Shahbaz FI, Valizadeh Kamran K. Effect of slope position on soil properties and types along an elevation gradient of arasbaran forest, Iran. *Int. J. Adv. Sci. Eng. Inf. Technol.* 2015;5:449.
- Khormali F, Ayoubi S, Foomani FK, Fatemi A. Tea yield and soil properties as affected by slope position and aspect in Lahijan area, Iran. *int. J. Plant prod. Prod.* 2007;1:99–111.
- Chen YF, Liu YS, Wang J, Yan JP, Guo XD. Land use changes of an aeolian-loessial soil area in northwest China: implications for ecological restoration. *Pedosphere.* 2009;19(3):356–361.
- Venterea RT, Lovett GM, Groffman PM, Schwarz PA. landscape patterns of net nitrification in a northern hardwood-conifer forest. *Soil Sci. Soc. Am. J.* 2003;67(2): 527–539.
- Arsyad S. *Pengawetan tanah dan air.* Dep. Ilmu Tanah Fak. Pertanian, Itb, Bogor; 2000.
- Island L. *Pocket guide to landscape soil health.* 1–64.
- Endriani. Sifat fisika dan kadar air tanah akibat penerapan olah tanah konservasi. *J. Hidrolitan.* 2010;1:26–34.
- Bayer. Napier grass - A promising fodder for smallholder livestock production in the tropics. *Plant Res. Adn Dev.* 1990;103–122.
- Orodho AB. The role and importance of napier grass in the smallholder dairy industry in Kenya. *Food Agric. Organ. Rome*) Retrieved August. 2006;24:29.
- Budiman RD, Soetrisno SPS, Budhi, Indrianto A. Morphological characteristics, productivity and quality of three napier grass (*pennisetum purpureum* schum) cultivars harvested at different age. *j. indones. Trop. Anim. Agric.* 2012;37(4): 294–301.
- Turano B, Tiwari UP, Jha R. Growth and nutritional evaluation of napier grass hybrids as forage for ruminants. *Trop. Grasslands-forrajes Trop.* 2016;4(3):168–178.
- Soil CL. Pengaruh pemberian bahan organik pada tanah liat dan lempung berliat terhadap kemampuan mengikat air. *J. Ilmu Pertan. Indones.* 2011;16(2):130–135.
- Ako A. Pengaruh tingkat pembew pupuk kandang terhadap pertumbuhan dan produksr rumput gajah (*Pennisetum purpureum* schumach) dan sorgum (*Sorghum bicolor* moench). *Pastura J. Ilmu Tumbuh. Pakan Ternak.* 1997;4(2).

20. Priangga Suwarno RS, Hidayat nur. Pengaruh level pupuk organik cair terhadap produksi bahan kering dan imbalanced daun-batang rumput gajah defoliasi keempat (the level effect of liquid organic fertilizer: Their effects on dry matter production and leaf to stem ratio of elephant grass at 4. J. Ilm. Peternak. Jurnal Ilmiah Peternakan. 2013; 1(1).

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