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Effects of Green Manure and Clay on the Soil Characteristics, Growth and Yield of Peanut at the Coastal Sandy Soil

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ABSTRACT

Effects of Green Manure and Clay on the Soil Characteristics, Growth and Yield of Peanut at the Coastal Sandy Soil (Muchtar and Y Soelaeman): Poor physical properties and limited amount of available nutrients were regarded as two main constraints possessed by coastal sandy soil for agricultural production. The objective of the study was to identify the effect of green manure and clay soil applications toward soils characteristic, growth and yield of peanut (*Arachis hypogeae* L.) in the coastal sand soil. A completely randomized design with factorial pattern 4 x 5 was applied in this experiment. The first factors were the rate of green manure application consisted of four levels, i.e. control, 5 Mg ha^{-1}, 10 Mg ha^{-1} and 15 Mg ha^{-1} of green manures. The second factors were the addition of five different levels of clay, *i.e*. control, Vertisol, Alfisol, Inceptisol and Vertisol + Alfisol + Inceptisol. Each treatment combinations were replicated three times. Results of the study showed that the vertisol soil affecting physical characteristics of soil. The addition of Inceptisol soil affected chemical characteristic of soil, increased growth and yield of peanut. Application of 15 Mg ha^{-1} of green manures affected toward the characteristic of soils except of the crop yields. However, there was no significant interaction effect from both materials to all variables observed.

Keywords: Clay, coastal sandy soil, green manure, peanut, soil characteristic

INTRODUCTION

An agricultural sector have a vital roles in national economy that was showed on its contributions to gross domestic product, employment and foreign exchange. The problem comes up in recent times was the reduction of agricultural land in lines with increasing population growth rate and the need of residential/housing and other facilities. In case of limitation of agricultural land, that was done efforts to expand planting areas, but there was in the direction of agricultural development to marginal lands (Kertonegoro 2001).

The coastal sandy land has marginal land and did not fully utilize to improve the welfare of the communities. Partly of some observers of agricultural issues suggested that cultivation of coastal sandy land for agricultural purposes was probably impossible. According to Partoyo (2005), the actual suitability of coastal sandy land based on the criteria of CSR/FAO (1983) was categorized to unsuitable or marginally suitable classes for food crops and vegetables. However, some research results showed that giving some treatments to the soil have tended to improve plant yield even though the yield was not optimal yet.

The coastal sandy land that was formed from sand materials was the soil that has not developed yet and was often found in very diverse parent materials, the type, nature as well as origin (Syukur 2005a). The coastal sandy land was contains of more than 80% of sands, poor soil structure, loose consistency, less water holding capacity, permeability and drainage were very rapid, and poor nutrients as the limiting factor of land productivity (Martini and Hendrata 2008). Siradz and Kabirun (2007) reported that the soil characteristics of mentions above with accompanied with high temperature of soil surface and high velocity of wind resulted very high

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evaporation. These soil characteristics were unfavorable for plant growth. Some various problems existed in coastal sandy soil needs to be solved to increase land productivity for plant growth, that was which in turn will improve people's welfare inhabited in the coastal areas.

To increase crops productivity in the coastal sandy soil should be used various technologies, so that the land will give benefit to the agricultural sector. In order to solve these problems needs to use organic matters in the form of green manure and it was accompanied with clay materials.

The use of organic matter in the form of plant residues or green manures to improve soil fertility has long been done by farmers that were an alternative solution to manage sustainable agriculture. The native soil organic matter has direct and indirect effects to soil physical properties such as to improve soil ability to hold water and to increase soil aggregate stability (Idawati and Haryanto 2005).

Organic materials will be effective to stabilize soil aggregate when it was combined with clay. Increasing stability of soil aggregates will affect to the other soil property changes in sandy soil, thus the addition of clay and organic matters into the sandy soil should be considered. The addition of organic materials that can be decomposed will formed complex organic compounds that will be binding the soil particles to the structural units, its called aggregates (Stevenson 1982).

The research of using of green manures on coastal sandy soil was not much studied, as well as informations of the use of clay to soil was varied. These research objectives were to find out the clay type and appropriate green manures dosages to achieve optimal yield. It is expected that using of clay and green manures in proper proportions, the obstacles faced in the cultivation of coastal sandy soil can be overcome, so that the land can be developed to more productive agricultural land.

MATERIALS AND METHODS

This research was a pot experiment conducted at greenhouse and soil analysis performed at the Soil Science Laboratory, Faculty of Agriculture, Gajah Mada University from February to September 2005.

Sandy soil samples were collected from Samas coastal areas of Bantul Regency, clay soils (Vertisol, Alfisol and Inceptisol) were obtained from Gunung Kidul Regency. The organic materials in the form of green manure of gamal leaves *(Gliricidia sepium)* was obtained from surrounding Yogyakarta regency and the indicator plants used was peanut *(Arachis hypogeae* L.).

The experiment was arranged in a factorial design using completely randomized block. Each treatment was repeated 3 times. The first factor was gamal leaf as a green manure, consisting of 4 dosages, namely: control, 5 Mg ha^{-1}, 10 Mg ha^{-1}, and 15 Mg ha^{-1}. The second factor was clay soil consists of 5 treatments, namely: control, Vertisol, Alfisol, Inceptisol, and mixtures of Vertisol + Inceptisol + Alfisol. The clay soil was added to each treatment at the dosages of 10% by weight of air dried soil.

The coastal sandy soil and clay soil have air dried and sieved to pass a 2 mm sieve, the green manure was chopped up to fine and weighted according to each treatment, and then mixed until homogeneous by hand. A mixture of coastal sandy soil, clay soil and fine green manure were relocated to plastic pots (soil weight pot^{-1} was 15 kg) and it was incubated in 45 days. After the incubation period has been ended, planting was done using 2 seeds of peanut for each pot experiment.

Parameters to be measured during the study were soil texture, bulk density (BD), total porosity, aggregate stability, soil permeability, soil pH, total-N, organic-C, organic materials, and C/N ratio.

Data were analyzed using analysis of variance (except for the data before treatment). For the treatments that showed significant different was continued by Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Initial Soil Properties

Table 1 showed that the coastal sandy soil acidity was rather acid, has a coarse texture and very high soil bulk density. The bulk density of the coastal sandy soil was affected by the low contents of soil organic matter, soil was dominated by iron minerals, and rough of soil texture. The soil contains high sand fraction there were large amount of soil macro pores compared to micro pores and the soil has high permeability. Based on these characteristics there were a great leaching process in the soil, a lot of nutrients lost from the soil. This was indicated by low soil nutrient content also was caused by low native content of nutrient elements in the soil. According to these characteristics, the soil was less

Table 1. The initial soil physical and chemical properties of coastal sandy soil from Samas and clay soil collected from Gunung Kidul Regency.

Soil Chracteristic	Sand	Vertisol	Alfisol	Inceptisol
Fraction Content				
- Sand (%)	98	8	30	11
- Silt (%)	1	15	28	14
- Clay (%)	1	77	42	75
Texture Class (USDA)	Sand	Clay	Clay	Clay
Particle Density (g cm^{-3})	3.16	1.74	1.96	1.85
Bulk Density (g cm^{-3})	1.92	1.24	1.46	1.37
Total Porosity (% volume)	39.24	31.03	25.51	25.95
Permeability (cm $hour^{-1}$)	116.32	0.18	42.8	3.60
pH H_2O	6.19	6.41	5.37	5.23
pH KCl	6.12	6.24	4.60	4.57
Organic Materials (%)	0.15	3.22	3.08	3.85
Organic-C (%)	0.09	1.87	1.79	2.24
Total-N (%)	0.03	0.06	0.08	0.08
C/N Ratio	3.21	31.17	23.87	28.00

fertile both physical and chemical properties and should be improved to get an optimum productivity.

Silt and clay contents of the coastal sandy soil were very low caused by low soil particles and bulk densities. Giving clay soils to the coastal sandy soil was important to increase the ability of binding force to store water that will be absorbed by plant roots. The high contents of clay and organic materials in the soil can support the formation of soil aggregates as a source of nutrients as well (Brady 1990). The limitation of clay soil was inefficient water drainage and poor soil aeration due to soft and solid soil structure compared to sandy soil.

The kind of of green manure used in this experiment was *Gliricidia sepium* leaves which the previous analysis of physical and chemical properties were presented in Table 2.

Green manures as a source of soil organic matter has an important function in the soil. The organic materials that has been decomposed will give an indirect benefit to plant growth by increasing of soil aggregate stability, cation exchange capacity, increasing nutrient elements and reducing the nutrients loses by leaching (Nuraida and Muchtar 2006).

Table 2. The chemical and physical properties of green manure of *Gliricidia sepium* leaves.

Analysis	Values
Water content (% weight)	46.4
pH H_2O	5.81
pH KCl	5.73
Organic-C (%)	14.02
Organic Materials (%)	24.10
Total-N (%)	1.08
C/N Ratio	13.03

Changes of Soil Physical Properties of the Coastal Sandy Soil

Soil Texture

Changes of sand, silt and clay percentages in the soil will cause to the change of soil texture class, further more, it will affect to the others soil physical properties such as soil bulk density, total soil porosity, soil aggregate stability and soil permeability. The results of soil analysis indicated that the sand fraction contents in the soil in all treatments decreased from 98% to between 89 to 92%.

Bulk Density (BD)

The soil bulk density was representing of ratio between the volumes of a solid mass to the total volume, including soil pore space. The results of soil analysis (Table 3) showed that the soil bulk density with addition of clay soil decreased significantly compared to the control. The lowest values of bulk density were gained by clay treatment of Vertisol that was 1.77 g cm^{-3} while the control treatment has a highest soil bulk density, there was 1.89 g cm^{-3}. Application of clays from Alfisol, Inceptisols and

Table 3. Bulk density, total porosity, aggregate stability and permeability of the coastal sandy soil by adding of green manure and clay soil.

Treatment	BD (g cm^{-3})	Total Porosity (%)	Aggregate Stability (%)	Permeability (cm $hour^{-1}$)
Clay Soil				
- Control	1.89 c	37.89 a	32.54 a	99.77 b
- Vertisol	1.77 a	39.86 b	41.02 b	53.35 a
- Alfisol	1.84 b	38.26 a	39.22 b	66.42 a
- Inceptisol	1.82 b	38.43 a	40.41 b	54.76 a
- Vt + Af + Icp	1.83 b	38.43 a	39.48 b	62.74 a
Green Manure				
- Control	1.86 r	38.09 p	35.34 p	82.85 r
- 5 Mg ha^{-1}	1.84 qr	38.41 pq	37.28 pq	71.11 qr
- 10 Mg ha^{-1}	1.82 q	38.62 pq	38.97 q	62.94 pq
- 15 Mg ha^{-1}	1.79 p	39.18 q	42.55 r	52.73 p

Notes: Numbers followed by the same letter in the same columns are not significantly different by DMRT at 0.05. Vt = Vertisol; Af = Alfisol and Icp = inceptisol.

mixtures of them showed not significant different, there were ranges between 1.82 to 1.84 g cm^{-3}. Addition of green manure gave significant impact to the soil characteristic, where the higher the proportion of green manures, the more obvious influence on the soil bulk density, while the interaction between application of clay and green manures showed not significant different.

Total Porosity

Porosity is the ratio between the total pore volumes to the volume of soil. Pore space is a sign of soil aggregation, so that the good soil structure has good soil porosity (Brady 1990). The results of soil porosity analysis (Table 3) showed that the soil porosity tends to increase with the addition of clay soil compared to the control treatment that has the lowest total porosity (37.89%). The highest values of total porosity of soil were found in Vertisol treatment (39.86%). The addition of green manures also gave significant impact to the soil characteristics, that was the fact that using of more higher proportion of green manures tend to more significant impacts in increasing of total soil porosity. The interaction between clays and green manures showed no significant different. According to Mowidu (2001), applications of 20 to 30 Mg ha^{-1} of organic matters showed significant effect to improve total soil porosity, usefull pore number, number of depositor pores to retain water/soil humidity, aggregate stability, and decreasing particle density, clod density and permeability.

Aggregate Stability

The results of aggregate stability analysis (Table 3) showed that the addition of clay gave a significant increased to soil aggregate stability of coastal sandy soil compared to the controls treatment. It seems that the treatment of Vertisol gave highest of soil aggregate stability. Additional of green manure was also significantly increases the values of soil aggregate stability of the coastal sandy soil. Using of 5 Mg ha^{-1} of green manure did not gave a significant values of aggregate stability compared to control treatment, the higher the doseges used of green manures the higher the values of soil aggregate stability. Interaction between clays and green manures application to the coastal sandy soil showed no significant effect.

Improving soil aggregate created a better soil physical environment for the development of plant roots and nutrient availability. It was because the good soil aggregation will ensure that the air and soil water was good too, so that the activity of microorganisms will be run well and improved nutrient availability in the soil. The soil that has less stable aggregates, when was disturbance, will be easily destroyed. Refined soil grains would filled the soil pores so that the weight volume of soil increases, poor aeration and soil permeability to be slow (Syukur 2005b).

Permeability

Soil permeability is the ability of soil to pass water and air, usually measured by the rate of water flow through the soil in a given time period (Yulius

Table 4. Soil pH, total-N, organic-C, organic matter and C/N ratio of the coastal sandy soil affected by addition of green manure and clay soil.

Treatment	Soil pH	Total-N (%)	Organic-C (%)	Organic matter (%)	C/N Ratio
Clay Soil					
- Control	6.16 b	0.02 a	0.12 a	0.21 a	6.79 a
- Vertisol	6.27 c	0.10 b	0.96 b	1.65 b	15.17 a
- Alfisol	6.09 a	0.10 b	0.89 b	1.53 b	13.78 a
- Inceptisol	6.17 b	0.12 b	1.12 c	1.92 c	18.70 a
- Vt + Af + Icp	6.07 a	0.11 b	1.09 c	1.88 c	14.47 a
Green Manure					
- Control	6.11 p	0.09 q	0.66 p	1.13 p	11.32 pq
- 5 Mg ha^{-1}	6.14 pq	0.05 p	0.89 q	1.53 q	17.41 qr
- 10 Mg ha^{-1}	6.16 pq	0.07 pq	0.90 q	1.54 q	19.28 r
- 15 Mg ha^{-1}	6.19 q	0.15 r	0.91 q	1.56 q	7.12 p
Interaction	(ns)	(ns)	(ns)	(ns)	(ns)

Notes: Numbers followed by the same letter in the same columns are not significantly different by DMRT at 0.05 and (ns) = not significant. Vt = Vertisol; Af = Alfisol and Icp = inceptisol.

et al. 1987). Results of analysis (Table 3) showed that the addition of clay significantly decreased the permeability of the coastal sandy soil while the control treatment gave the highest soil permeability. The addition of green manure also reduced the permeability of the sandy soil significantly compared to controls. The interaction between the treatments of clay with the addition of green manure showed no significant effect.

Permeability values are affected by soil aggregate stability. The soil with the highest aggregate stability has low permeability because the soil with high aggregate stability will be easily dispersed by water becomes very fine grains (clay). The dispersed soil grains will clog the soil pores, consequently affected to decrease of soil permeability (Junaedi 2008).

Changes of Chemical Properties of the Coastal Sandy Soil

Soil pH

Research results showed that the addition of Vertisol clay gave the highest soil pH significantly (6.27) compared to the other treatments. The soil pH that was treated by the clay of Alfisol and mixture of Vertisol, Alfisol and Inceptisol were lower compared to the control treatment (Table 4). The addition of 15 Mg ha^{-1} of green manure was also likely to increase soil pH significantly compared to control, while the addition of 5 to 10 Mg ha^{-1} of green manures did not give significant different of soil pH compared to the control treatment even though the soil pH values of green manures treatments tend to be higher.

Increased of soil pH was the result of the decomposition process of organic materials given to produce bases cations. The interaction between clays and organic manures treatments showed no significant influence to soil pH of the coastal sandy soil.

Total-N

The results of soil analysis showed that the addition of clays were significantly increased total-N in the coastal sandy soil compared to control. Table 4 showed that the soil treatmented by Inceptisol gave the highest value of total-N, it was an average of 0.12%. Addition of 15 Mg ha^{-1} of green manure also tends to increase total-N of the coastal sandy soil significantly compared to the control treatment, the higher than 15 Mg ha^{-1} estimated to increase the contents of total-N in the soil. This performance was estimated because occurring the adding processes of N to the soil from the green manure, so that increasing the dosage of nitrogen fertilizer will increase the total soil nitrogen. Interactions between the two treatment factors showed no significant effect.

Soil Organic-C and Soil Organic Matter

The results of soil analysis showed that the treatment of addition of clay to the coastal sandy soil was significantly increased organic-C and organic matter in the soil. Table 4 showed that the Inceptisols

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treatment gave highest effect to the soil organic-C and soil organic matter that were 1.12% and 1.92%, respectively. Addition of green manure was also tends to increase soil organic-C and soil organic matter in the coastal sand soil significantly compared to the control treatment. Interaction between the addition of clay and green manure showed no significant effect.

The results of soil analysis showed that the addition of green manures between 10 Mg ha^{-1} to 15 Mg ha^{-1} gave the highest soil organic-C and soil organic matter contents. Green manures provide another major source of organic food for soil microorganisms. In addition to the importance of green manures as starting materials for microbially produced soil humic substances, other significant uses for green manures must be considered such as omprovement of soil aggregation; and transport and retention of water, heat and air in the soil. The more organic materials given to the soil will be the higher value of soil organic-C (Yulius *et al*. 1987).

Research results found by Syukur and Indah (2003) showed that the application of 10 Mg ha^{-1} of green manure/organic fertilizer increased the levels of soil organic-C from 1.35% to 1.785% that was indicated not significantly different compared to the application of 20 Mg ha^{-1} of organic fertilizer. Application of 10 Mg ha^{-1} of organic fertilizer also had capability to increase soil total-N from 0.075% to 0.109% and showed not significantly different compared to the use of 20 Mg ha^{-1} of organic fertilizer.

C/N ratio

The results of soil analysis showed that the addition of green manure gave significant impact to the value of soil C/N ratio, but the addition of clay and interaction between clays and green manures did not show a significant different. The results of soil analysis showed that the soil treatment by adding of 15 Mg ha^{-1} of green manure gave the low values of C/N ratio in the soil (7.12%). There was expected that the large addition of green manure has caused to the increasing of decomposer microbes population.

The high value of C/N ratio can be caused by the low release of C and high release of N; otherwise the low value of C/N ratio can be caused by the high release of C and low release of N or low release of C followed by the low release of N. The results of soil analysis showed increasing content of soil organic-C, total-N and soil organic matter from the original/ native soil contents level. These facts indicated that there have occurred the release of C in the form of CO_2 and N in the form of NO_2, N_2O and/or of N_2 with varying levels, this causes the C/N ratio in the soil was varies (Stevenson 1982; Brady 1990).

Growth and Yield of Peanut at the Coastal Sandy Soil

Plant Height

Addition of green manure and clay soil into the soil increased plant height significantly in all treatments in line of increasing of plant age. Development of plant height without clay soil and green manure treatments was lower compared to the treatment with clay soil and green manure. Plant growth has a relationship with the amount of nutrients applicated and water availability in the soil.

Nitrogen has a characteristic easily to carry by water gravity, there was often found on sandy soil in which has a high macro porous to pass water easily. Clay soil has ability to retain water and supplied plant

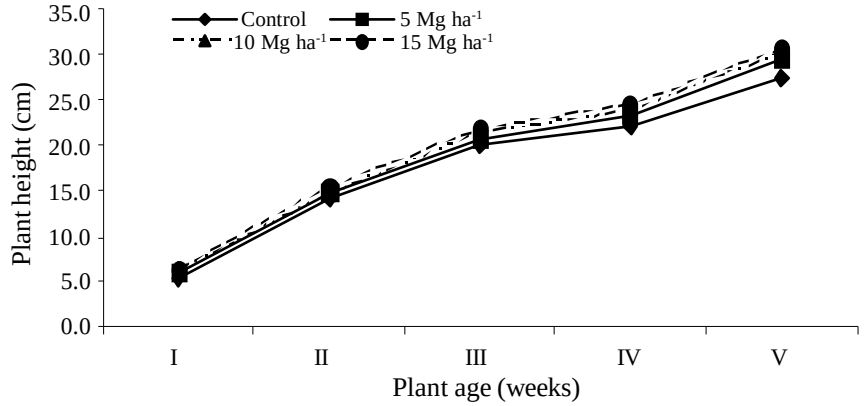


Figure 1. Plant height of peanut at 1 to 5 weeks after planting (cm) affected by adding of clay.

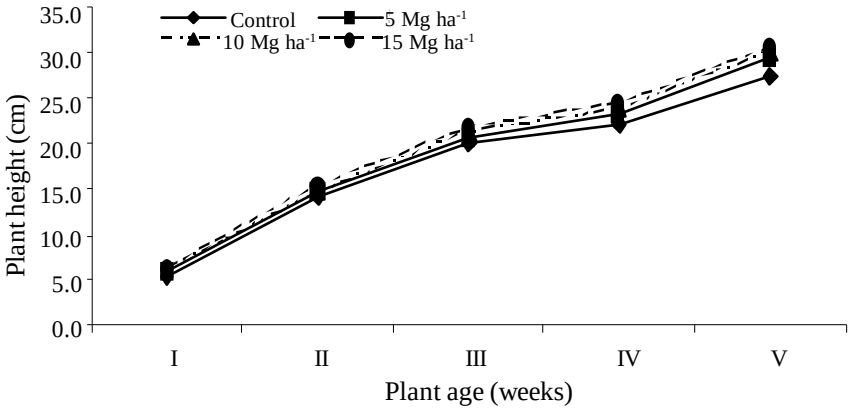


Figure 2. Plant height of peanut at 1 to 5 weeks after planting (cm) effected by adding of green manure.

nutrients so that the leaching losses of soluble N can be reduced and will be available for plants growth. Increasing of N contents in the soil will improve plants vegetative growth. Nitrogen plays an important role as a constituent of chlorophyl that makes leaves green (Astiningrum 1996).

The following figure presented the peanut plant height at 1 to 5 week(s) after planting were effected by adding of clay and green manure on the coastal sandy soil.

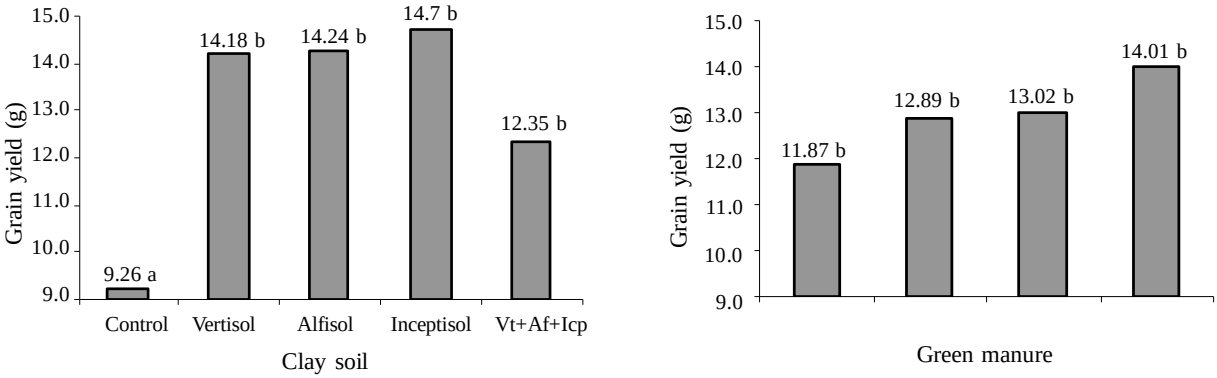
Grain Yield

Research results showed that the addition of clay treatment significantly increased the yield of peanut compared to the control treatment. Treatment of inceptisol gave highest grain yield, while the addition of green manure and interaction between clay and green manure did not affect peanut yield.

Grain yield weight associated with nutrient and water availability in the soil. Green manure contained nutrient elements that were needed by crops in the process of photosynthesis, respiration and biochemical processes in crops and affected crops growth, the age of flowering, seed maturity and grain yields.

The addition of clay to the soil increased water holding capacity so that the water in the soil will be available for crop growth. The water was needed during generative phase of crops especially in the flowering stage, pod formation and seed filling. The availability of nutrient elements in the soil strongly supported to the physiological processes of crops, leaf area and better plant stem growth, that allowed plant organs/leaves processed maximum photosynthesis and translocated to the seed maximally (Astiningrum 1996). Grain yield of peanut were presented in Figure 3.

Increasing of crop yields was closely related to the soil organic matter content, soil bulk density and soil permeability. Organic matters produced nutrient



Note: Figures followed by the same letter was not significantly different based on the Duncan test of 5% level

Figure 3. Grain yield of peanut affected by giving a clay soil and green manure.

elements that used by the crops to survive, also the organic matter as a glue of soil grains so that the soil becomes loosely that were resulting to the low soil bulk density values. Loose soil allowed the crop roots growth well and absorbs nutrients. Good soil permeability will absorb water into the roots areas so that the water needed by plant was gained. The availability of nutrients element and water will increased crop growth, which in turn increased crop yields (Junaedi 2008).

CONCLUSIONS

The vertisol clay was added to the coastal sandy soil gave more significant effect on the soil physical properties observed (BD, porosity, aggregate stability and permeability) due to the original of soil physical properties of vertisol was better than the other clay used. The inceptisol clay added to the coastal sandy soil showed significant effects on the soil chemistry parameters, crop growth and yield (soil pH, total-N, organic-C, organic matter, plant height and plant yield).

Giving the green manures on the dosage of 15 $Mg\ ha^{-1}$ gave the different impact on all parameters observed, except on the crop yields. Interaction between clay and green manures treatments did not give significant effects to all parameters observed, these means that the clay treatment worked alone or was not affected by the treatment of green manure, and vice versa.

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