EFFECTS OF STEEL SLAG AND BOKASHI OF HUSK ON SOIL BULK DENSITY, AGGREGATE STABILITY AND POROSITY OF ANDISOL

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ABSTRACT

Andisol has a distinguishing soil physical characteristic, but it has problem with the P retention. Giving ameliorant to reduce the P retention is expected to maintain, moreover to improve some soil physical characteristics. The objective of this research was to find out the interaction between steel slag and bokashi of husk to bulk density, aggregate stability, soil porosity and biomass of broccoli on Andisol Lembang. This study used a randomized block design factorial with two factors. The first factor was steel slag and the second factor was bokashi of husk. Each of them consisted of 4 levels : 0%, 2.5%, 5.0% and 7.5% with two replications. The result of this research showed there was not interaction between steel slag and bokashi of husk to soil bulk density, soil aggregate stability, soil porosity and biomass of broccoli. The statistical results showed that bokashi of husk influence independently to decreasing soil bulk density until 0.53 g cm^{-3}, decreasing soil aggregate stability until 3.25 and increasing soil porosity until 80.22%, but the provision of steel slag and bokashi of husk didn't influence to biomass of broccoli.

Key words: P-retention, bulk density, permeability, aggregate stability

INTRODUCTION

Andisol derives from volcanic ash parent material (Devnita, 2010) with andic soil characteristic characterized by C-organic content 25% or less, bulk density 0,9 g cm^{-3} or less, P retention is more than 85% and amount of Al + ½ Fe percentages of more than 2,0% extracted with ammonium oxalate (Soil Survey Staff, 2014).

Andisol has a high potential for agriculture because it has excellent some soil physicals and chemical characteristics, such as low soil bulk density, high permeability, high organic matter content and high nutrient content. However, Andisol has problem with high P retention and low P availability.

The low availability of P in Andisol is caused by the high afinity. It‘s clay minerals like allophane, imogolite, ferrihydrite and Al-humus complexes (Hardjowigeno, 2003). Allophane is highly reactive (Sukmawati, 2011) due to the large specific surface area (Uehara and Gillman, 1982) and active positive charged functional groups (Bohn et al., 1979), that can bind the negative charged of phosphate. It causes the P retention on Andisol is very high, that can be 85% or more.

Silicates and organic matter are the anions with high negative charged, therefore they can replace the retain phosphate (Tan, 2001). Silicates and organic matter not only can decrease P retention, but also can decrease bulk density, increase the P availability, aggregate stability and water available (Rashid, 2012; Sukmawati, 2011; Ardiyanto, 2009; Putri, 2010 and Jamil et al., 2006). Steel slag and bokashi of husk can be used as the source of silicate and organic matter.

Steel slag is a byproduct of the refining of iron in steel making (Ismunadji et al, 1991). Steel slag has been used for long time for agriculture, as a source of P, Si and lime (Rex, 2002). Silicate can increase the meso pore (Princess, 2010), stimulate the plant growth and also can be an important element for some certain plant (Yukamgo and Yowono, 2007).

Organic matter can improve soil chemical characteristic by increasing the P availability in soil (Stevenson, 1982) and decreasing the P retention through the organic acids as a results of weathering product of organic matter. (Jamil et al. , 2006). Organic matter also can improve physical characteristic by forming and stabilizing soil aggregates. Organic matter is able to bind a single particle into an aggregate to create more pore spaces between the aggregates. Organic matter also can increase plant biomass (Yulnafatmawita, 2006).

Broccoli produces flowers and needs P for growth. Phosphor is macro nutrient that important for stimulate root growth, plant growth, accelerate the maturity of the fruit and seeds (Suyono et al., 2008) and crop production (Rashid, 2012).

Research on the influence of steel slag and bokashi of husk to P retention, P avaibility and chemical characteristics has been found in several publication, but effect of the treatments to the soil physical characteristics has not been found yet. The objective of this research was to find out the effect to physical characteristics, such as bulk density, aggregate stability, soil porosity and biomass.

MATERIALS DAN METHODS

This research was conducted at the Balai Penelitian Tanaman Sayuran (Balitsa) Lembang, on September until February 2014. The research used randomized block design (RBD) factorial with two factors. The first factor was steel slag and the second factor was bokashi of husk each consisted 4 levels: 0%, 2.5%, 5.0% and 7.5% with two replications. Total treatments were 4x4x2 = 32. The combination of treatments can be seen in Table 1.

Table 1: Combination Treatment of Steel Slag and Bokashi of husk.

Steel Slag (T)	Bokashi of husk (B)			
	b_0	b_1	b_2	b_3
t_0	t_0b_0	t_0b_1	t_0b_2	t_0b_3
t_1	t_1b_0	t_1b_1	t_1b_2	t_1b_3
t_2	t_2b_0	t_2b_1	t_2b_2	t_2b_3
t_3	t_3b_0	t_3b_1	t_3b_2	t_3b_3

The soil used in this reseach taken at some point in the Balitsa with depth of 0-20 cm. Before growing of plant, soil was incubated with steel slag with a large bulk density was 1.7 g cm^{-3} and bokashi of husk with a small bulk density was 0.9 g cm^{-3}. The mixtures of soil with defined treatments were then filled into 32 polybags (diameters of 60 cm to a depth of 60 cm) for 4 months while incubating soil was weighed every 1 week 2 times and water levels maintained in field capacity. After incubation for 4 months, brokoli was plant in each polybag. Steel slag obtained from PT. Krakatau Steel and bokashi of husk has been made in Pedca Unpad.

Fertilizer used was 200 kg ha^{-1} urea, 250 kg ha^{-1} SP-36 and 200 kg ha^{-1} KCl with spacing of 60 cm x 40 cm. Broccoli can be harvested after the age of 72 days

(Wasonowati, 2009), after reaching the end of the generative phase (harvest). Soil samples were taken with ring sample and clod. Undisturbed soil samples taken with ring samples were used for measuring bulk density and soil porosity. Soil agreggate stability taken with clod and plants taken to weigh for plant biomass, were the plant roots and vanished.

Method to determinated bulk density used clod, soil agreggate stability used loveday dan soil porosity used gravimetric, further analysis was conducted in the Conservation and Soil Physics Laboratory, Department of Soil Science and Land Resources, Faculty of Agriculture, University of Padjadjaran and Soil Physics Laboratory, Department of Soil Science and Land Resources, Faculty of Agriculture, Bogor Agricultural University.

RESULTS AND DISCUSSION

Bulk Density

Statistical analysis showed that there was no interaction between the steel slag and bokashi of husk to soil bulk density. The statistical results showed that the bokashi of husk independently decreased the bulk density. However steel slag had not influence to the bulk density, as can be seen in Table 2.

Table 2. Influence Bokashi of Husk and Steel Slag to Bulk Density.

Treatment Bokashi of husk (B) and Steel Slag (T)	Bulk Density
b_0 (without bokashi of husk / control)	0.79 a
b_1 (2.5 % bokashi of husk)	0.69 b
b_2 (5.0 % bokashi of husk)	0.59 c
b_3 (7.5 % bokashi of husk)	0.53 d

Remarks: Figures followed by the same letter, are not significantly different according to Duncan's Multiple Range Test at the 5% level.

Data in Table 2 showed that the bokashi of husk influenced in the decreasing of soil bulk density. The increasing dosage of bokashi of husk, caused the decreasing of the soil bulk density. The lowest bulk density (0.53) was obtained at the dosage of 7.5% bokashi of husk. However, the dosage of 2.5% and 5.0% had already decreased the soil bulk density compared to the control.

Bulk density was an indication of the density of the soil. The more dense the soil, the higher bulk density, make the root more difficult to penetrate the soil. Increasing soil organic matter content can maintain the quality of soil physics to help the development of plant roots (Hairiah, 2000). The increasing of roots will improve the absorbtion of the nutrients (Wigati et al, 2006).

Plant roots also contributed to the abundance of organic matter in the soil that acted as an adhesive (binder) of soil particles, therefore the aggregation in soil would be stable, pore space would be increase and bulk density would be decrease. This was in line with Mariana (2006) mentioned that the organic matter when applied to the soil would create pore space and reduce the soil bulk density. In this research, steel slag didn't influence the soil bulk density. Because the steel slag volumetrically was less than bokashi of husk.

Soil Aggregates Stability

Statistical analysis showed that there was no interaction between the steel slag and bokashi of husk to soil aggregate stability. The statistical results showed that the bokashi of husk independently improve the soil aggregate stability, steel slag had not influence to the soil aggregate stability, as can be seen in Table 3.

Table 3. Influence Bokashi of Husk and Steel Slag to Soil Aggregate Stability

Treatment Bokashi of husk (B) and Steel Slag (T)	Soil Aggregate Stability
b_0 (without bokashi of husk / control)	6.75 a
b_1 (2.5 % bokashi of husk)	3.75 b
b_2 (5.0 % bokashi of husk)	3.25 b
b_3 (7.5 % bokashi of husk)	3.25 b

Remarks: Figures followed by the same letter, are not significantly different according to Duncan's Multiple Range Test at the 5% level.

Data in Table 3 showed that the bokashi of husk increased the soil agreggate stability. The smaller value of soil agreggate stability would form the more stable soil agreggate. The increasing dosage of bokashi of husk caused the more stable soil agreggate. The lowest soil agreggate stability (3.25) obtained at the dosage of 5.0% and 7.5% bokashi of husk. However, the dosage of 2.5% have already increased the soil agreggate stability compared to the control. Bokashi of husk influenced independently on the soil aggregate stability. This was caused bokashi of husk given volumetrically more than steel slag.

Bokashi of husk contains C- organic that had a high positive and negative charged. The negative charged of organic matter (carboxyl) that would bind to the negative charged clay domains with intermediate cations Ca, Mg, Fe and hydrogen bonding, while the positive charged of organic matter (amine, amide and amino) would bind with the clay domains negative charged (Sarief, 1989), so it would form a stable soil aggregates. Plant roots also contributed to the abundance of soil organic matter (Watts et al., 1993) that played a role in stabilizing soil aggregates by binding soil particles into aggregates.

Soil Porosity

Statistical analysis showed that there was no interaction between the steel slag and bokashi of husk to soil porosity. The statistical results showed that the bokashi of husk influenced increase the soil porosity. Steel slag had not influence, as can be seen in Table 4.

Table 4. Influence Bokashi of Husk and Steel Slag to Soil Porosity.

Treatment Bokashi of husk (B)	Soil Porosity (%)
b_0 (without bokashi of husk / control)	70.04 a
b_1 (2.5 % bokashi of husk)	73.88 b
b_2 (5.0 % bokashi of husk)	77.52 c
b_3 (7.5 % bokashi of husk)	80.22 d

Remarks: Figures followed by the same letter, are not significantly different according to Duncan's Multiple Range Test at the 5% level.

Data in Table 4 showed that the bokashi of husk increased the soil porosity. The increasing the dosage of bokashi of husk, caused the increasing of the soil porosity. The highest soil porosity (80.22) obtained at the dosage of 7.5% bokashi of husk. However, the dosage of 2.5% and 5% had already increased the soil porosity compared to the control. Hasanah (2009) showed that the value of soil would be optimal if soil porosity was greater than 50%.

The increasing meso pore would increase the air-filled pores and lower the water-filled pores, therefore would improved aeration in the soil. Organic matter would improve the total of soil pore and decreased soil bulk density (Wiskandar, 2002).

Soil porosity also could not be separated from other soil physical characteristic, like soil bulk density and aggregate stability. These physical characteristic were also closely associated with plant roots as a growing medium. Soil bulk density was one reflection of the differences in soil aggregate size, which indirectly affect the growth and yield of, due to its influence to soil porosity, water availability, aggregate stability and movement of roots in the soil (Alexander and Miller, 1991).

CONCLUSION

The results of this research showed that there was not interaction between the steel slag and bokashi of husk to soil bulk density, soil aggregate stability, soil porosity and biomass of broccoli. The statistical results showed that there was the influenced independently bokashi of husk to soil bulk density, soil aggregate stability and soil porosity at dosage of 2.5%.

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