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Dr. Afandi
Prof. Dr. Ken Hiramatsu

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Soil Compaction, Water Content, Bulk Density and Soil Root Biomass Affected by Tillage and Fertilizer on Gedung Meneng Soil under Green Bean Growth

Yogi Irawan[1], J. Lumbanraja[2], Nur Afni Afrianti[2], Afandi[2]
[1.] Under graduate students of Agriculture Faculty, Lampung University
[2.] Faculty of Agriculture, Lampung University

SUMMARY
To slow down soil degradation can be overcome with minimum tillage and proper fertilizer. The objective of research was to study the effect of tillage and fertilizer on soil compaction, water content, bulk density, and root biomass. This research used Randomized Block Design. The treatments consist of minimum tillage with no fertilizer (T_0F_0), minimum tillage with fertilizer (T_0F_1), intensive tillage with no fertilizer (T_1F_0), and intensive tillage with fertilizer (T_1F_1). The rate of fertilizer was 1 Mg compost ha^{-1} and 200 kg compound NPK ha^{-1}. The result of the research showed that minimum tillage affected the highest of soil compaction in the depth of 0-5 and 5-10 cm, water content in the depth of 0-10 cm before land preparation, and root biomass in the depth of 0-5 and 5-10 cm. Minimum tillage with no fertilizer had the highest water content in the depth of 0-10 cm before land preparation. The effect of minimum tillage with fertilizer on water content was higher than that of intensive tillage with fertilizer. The treatment of no fertilizer affected on water content was higher than that of with fertilizer at the depth of 10-20 cm.

Introduction

Green beans are one of the important leguminous plants in Indonesia (Sunantara, 2000). The productivity of green beans in Lampung is still relatively low compared to the productivity of green beans on Java (BPS, 2016). Increasing the productivity of green beans can be achieved by optimizing the cultivation land carried out with good cultivation techniques and proper fertilization.

One of the techniques of crop cultivation is tillage. Improper tillage such as intensive tillage in a long time can reduce soil physical properties (Junedi et al., 2013). Proper tillage can be done with conservation tillage like minimum tillage or just tillage on strip of cropping. (Rachman, et al., 2003).

Farmers generally only use inorganic fertilizers that are able to provide nutrients in a relatively faster (Dewanto, *et al.*, 2013). But if the employing of inorganic fertilizers with excessive rates but rarely use organic fertilizers, it will cause soil conditions to quickly damage (Prasetyo, et al., 2014).

Dewanto et al. (2013) stated that the combination between organic and inorganic fertilizer was able to produced 600 kg ha^{-1} of dry shelled weight of maize, while no fertilizer only produce 300 kg ha^{-1} of dry shelled weight of maize. This shows that the employing of inorganic fertilizers must be balanced with organic fertilizer.

Material and Method

This study was conducted using factorial Randomized Block Design (RBD) with 2 factors and 4 replications (groups). The plot area of each group is 2.5 x 2.5 m^2. The first factor in this study was tillage (minimum tillage and intensive tillage) and the second factor was fertilization (with no fertilizer and with fertilizer), so there were 4 combinations of treatments, minimum tillage with no fertilizer (T_0F_0), minimum tillage with fertilizer(T_0F_1), intensive tillage with no fertilizer (T_1F_0), and intensive tillage with fertilizer (T_1F_1). The fertilizer treatment given was 1 Mg compost ha^{-1} + 200 kg compound NPK ha^{-1}.

Observation of soil compaction, water content, and bulk density was carried out before land preparation and post planting (65 days after planting). Measuring of soil compaction is using penetrometer. The depth observed is 0-5, 5-10, 10-15, and 15-20 cm. Soil sampling for measuring of water content and bulk density were using ring with the depth of the soil was 0-10 cm and 10-20 cm. Taking samples of root biomass using a drill by the depth of 0-5, 5-10 and 10-15 cm at the time of 65 days after planting. The root biomass taken is plant root biomass which is around the roots of green beans. Data analysis by using variance analysis. Homogeneity of variance was tested by Bartlet Test, and then the differences between the mean values were tested by BNT at the levels of 5% and 1%.

Result and Discussions

Soil Properties

Banuwa, et al. (2011) classified the soil in experiment site was Ultisols, soil structure from blocky, platy, and

massive. with clay soil texture,bulk density between 1.13 - 1.21 g cm^{-3}, the total pore space ranged from 54.34 - 57.36%.

Soil Compaction

Soil compaction in minimum tillage was higher than in intensive tillage both before land preparation and post planting (Figure 1).

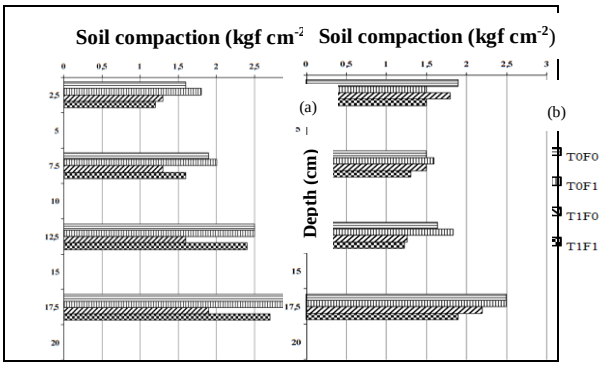

Fig 1. Soil compaction (kgf cm^{-2}) affected by tillage and fertilizer under green bean growth. (a) = before land preparation; (b) = after 65 days (post planting).

Water Content

Water content in the minimum tillage post planting significant higher than that of intensive tillage at the depth of 0-10 cm. This might due to the condition of the moisture in the minimum tillage being maintained, this causes the water content still high in the minimum tillage. Unlike with intensive tillage where the surface was open cause in rapid evaporation. This causes water content to be low.

The treatment with no fertilizer was significant in higher water content than that of the treatment with fertilizer of the soil before land preparation and after 65 days of planting. It was assumed that the combination of fertilizers between organic and inorganic at the beginning of planting was not in a balanced amount. If the organic fertilizer given was not in sufficient quantity, then the function of organic matter as a binder of water becomes reduced, while the inorganic fertilizer given absorbed water to dissolve the compound. As a result the water content in the land that given by fertilizer was reduced. Low water content can reduce microorganism activity. This was proven by Daniati (2018) who conducted research on the same land, but with different observation variables. Daniati (2018) stated that the activity of microorganisms in the treatment with no fertilizer was 6.14 mg^{-1} m^{-2}, while the treatment with fertilizers was only 4.82 mg^{-1} m^{-2}. Low microorganism activity in fertilizing treatment causes the decomposition process of organic matter which plays a role in binding water to be low. So that the water content in the fertilizer treatment is lower than with no fertilizer.

Figure 2 shows that the water content of all treatments of the time of post planting were higher than that of before land preparation. In the subsoil layer (10-20 cm), water content before land preparation showed a graph higher compared to the top layer (0-10 cm). This was presumably because the sub soil layer has less water loss due to evaporation than that of in the top soil layer, so that the water content in the sub soil layer is higher than the top soil layer.

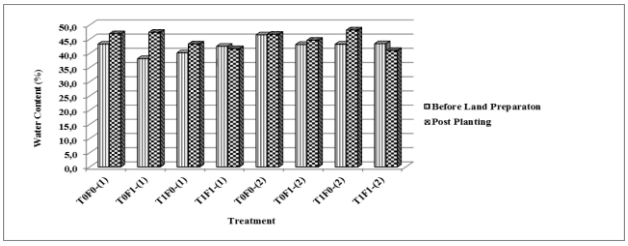

Fig 2. Water content affected by tillage and fertilizer under green bean growth

Bulk Density

Effect of the treatment on soil compaction was not significant different between before land preparation from and post planting. Solyati and Kusuma (2017) revealed that all treatments of soil tillage such as intensive tillage, minimum tillage, and no tillage were not significant on bulk density in 60 days after planting or just only one period of planting.

Figure 3 shows that the treatment given results in bulk density value ranging from 1.07 - 1.20 g cm^{-3}. According to Skop in Summer (2000), sandy soil that received pressure to produce a low pore space has a density of 1.4 - 1.9 g cm^{-3}, while clay soil which did not get high pressure from heavy loads will produce weight contents of 0.9 – 1. 4 g cm^{-3}. This shows that the bulk density is closely related to the type of texture and structure of the soil. According to Rachman (1987), if the soil was loose enough with bulk density less than 1.2 g cm^{-3}, then conservation tillage (no tillage or minimum tillage) was a highly recommended treatment method because the soil was sensitive to erosion.

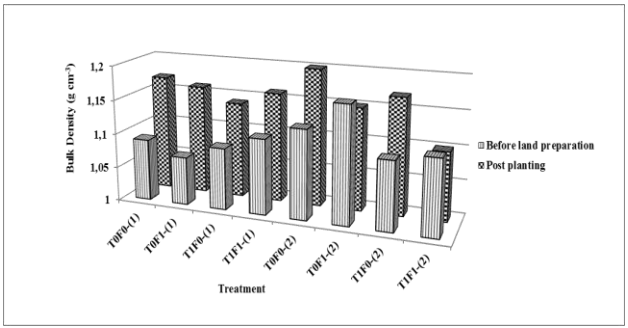

Fig 3.Bulk density affected by tillage and fertilizer under green bean growth.

The effect of treatments of tillage and fertilizer on the bulk density at the time of post planting tends to be higher than before land preparation.

Root Biomass

The effect of minimum tillage with fertilizer and with no fertilizer on root biomass was higher root biomass compared to that of intensive tillage with no fertilizer and with fertilizer. This could be due because of minimum tillage providing good growth space for plant roots. According to Wahyuni et al (2012) minimum tillage adequate to make a good soil structure and aggregate conditions compared to intensive tillage where in intensive tillage occur the process of flipping / unpacking the soil that could cause aggregate dispersion and pore blockage which could reduce the distribution of macro pores and increased micro pore amount (Wahyuni et al., 2012).

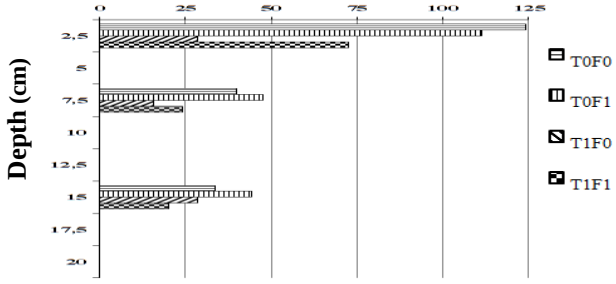

Fig 4. Root biomass (kg m^{-3}) affected by tillage and fertilizer.

Conclusion

Minimum tillage affected the highest compaction on the soil in the depth of 0-5 and 5-10 cm, water content in the depth of 0-10 cm before land preparation, and root biomass in the depth of 0-5 and 5-10 cm. Minimum tillage with no fertilizer affected the highest water content in the depth of 0-10 cm before land preparation. The effect of minimum tillage with fertilizer on water content was higher than that of intensive tillage with fertilizer. The treatment of no fertilizer affected on water content was higher than that of with fertilizer at the depth of 10-20 cm.

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