The effects of compaction on soil gaseous-transport properties

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1. Introduction

Soil compaction in agricultural field is mainly caused by farm machinery operations, and the compaction in turn may alter soil aeration by decreasing soil porosity. Organic matter (OM), on the other hand, is well known to enable to decrease the effects of compaction and improve other soil physical properties. However, effect of compaction on gaseous-transport properties of the OM-applied soil has not yet been fully documented. Thus, this study was aimed to investigate effects of compaction on relative gas diffusivity \( \frac{D_p}{D_0} \) and air permeability \( k_a \) \([\mu m^2]\) of the OM-applied soil.

2. Materials and method

Each of rice husk, rice straw, compost, sawdust, and wood bark was mixed with the sample of sandy loam soil at 20% volume, just prior to the compaction. The compaction was conducted at 70% water content (referred to control) for 150, 225, and 300 kPa using a modified triaxial test machine (static load). Afterward, the specimen was saturated with water, and then was drained at -100 cm \( H_2O \) soil matric suction (hanging water column method) for \( \frac{D_p}{D_0} \) and \( k_a \) measurements.

The measurement of \( \frac{D_p}{D_0} \) and \( k_a \) were performed in triplicate using a method from Kuncoro and Koga (2012). Calculation for \( \frac{D_p}{D_0} \) was based on the solution given by Currie (1960), while \( k_a \) was calculated based on the Darcy’s law.

Fig. 1 Mean of measured \( \frac{D_p}{D_0} \) for different level of compactions (same letter are not significantly different for Anova - Tukey HSD test \( P<0.05 \))

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3. Results and discussion

Figs. 1 and 2 show that $D_p/D_0$ and $k_a$ decreased with compaction levels, respectively, and the difference was significant between 300 kPa and 150 kPa. There was a tendency that incorporation of wood bark and sawdust increased $D_p/D_0$ and $k_a$, whereas rice straw and compost gave reverse effects.

Likewise, air content at -100 cm H$_2$O soil matric suction ($\varepsilon_{100}$), which also represents equivalent volume of soil macropore ($\phi \geq 30 \mu m$), decreased with compaction (data were not shown). On the other hand, Figs.3 and 4 show high positive linearity between $D_p/D_0$ and $\varepsilon_{100}$, and between $k_a$ and $\varepsilon_{100}$, respectively. Thus, the decrease in $D_p/D_0$ and $k_a$ with compaction in this study were considered to be attributed to the decrease in the air volume of soil macropore.

Further, for the same $\varepsilon_{100}$, control soil tended to result higher $D_p/D_0$ and $k_a$ than the OM-applied soil. This result may suggest an existence of such blockage effect from the applied OM on the soil gaseous-transport processes (pores became more tortuous).

4. Conclusion

Soil gas diffusivity ($D_p/D_0$) and air permeability ($k_a$) decreased with compaction level. The decrease in $D_p/D_0$ and $k_a$ was attributed to the decrease in the air volume of soil macropore, of which the effect was more distinct for $k_a$.

References
