モミ殻施用の影響を受けた攪乱締固めクロボク土のガス輸送特性の異方性

Anisotropy of soil gas transport properties of disturbed and compacted Japanese andisol as affected by existence of the applied rice husk

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1. Introduction

Anisotropic behavior of gas transport has been reported for undisturbed-compacted soil previously. To our knowledge, however, this behavior has been paid less attention for disturbed-compacted soil, besides effect of the applied organic matter on it is yet rarely documented. In this study, effect of the mixed rice husk on this anisotropic behavior has been investigated using disturbed-compacted Japanese andisol.

2. Materials and methods

Disturbed soil sample of a sandy loam volcanic ash andisol taken at a depth of 0–15 cm from “Takizawa” experimental field of Iwate University (39°46’58.70” N, 141°07’32.75” E) was lightly sieved (4.76 mm) and set for 72.15% in water content. Rice husk was then mixed with this sample at 20% rate by volume. Soil sample without rice husk mixing was taken as a control.

The sample was then repacked into a 5600 cm^3 soil box (20 cm wide, 20 cm long, and 14 cm high) and lightly tamped before compaction. The compaction was conducted using static load of 225 kPa in laboratory by which a block sample (20 cm in width, 20 cm in length, and about 9 cm in height) can be performed. This block sample was required to produce final specimens which allow either of vertical and horizontal measurements.

The final specimen was developed in the following manner. A cylindrical soil (9 cm wide and 9 cm long) was initially taken off from the aforementioned block sample after compaction. The cylindrical soil was taken parallel to direction of the compaction for vertical measurement, whereas it was taken perpendicular to direction of the compaction for horizontal measurement. The cylindrical soil was then housed into the targeted mould (471 cm^3 in volume with 10 cm in inner diameter and 6 cm in length) for which the space between the cylindrical soil and the targeted mould was filled with plastone (Fig. 1). Finally, excessive parts of the soil over the both ends of the targeted mould were trimmed to produce the final specimen.

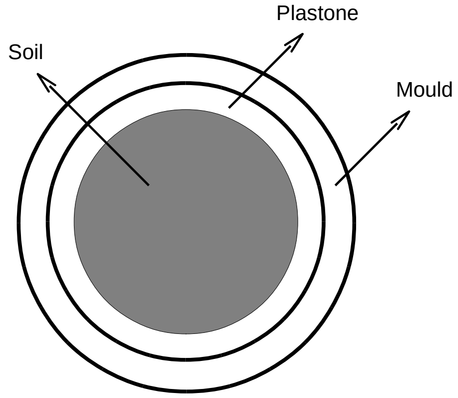

Fig. 1 Cross-section of the final soil specimen used for measurements

The developed final specimen was then preliminary saturated with water, and subsequently drained at -100 cm H_2O soil matric suction by the hanging water column method for measurement of relative gas diffusivity $(D_p/D_0)_{100}$ and air permeability k_{a100}. The measurement of $(D_p/D_0)_{100}$ and k_{a100} were conducted using method from Kuncoro and Koga (2012) as also used in Kuncoro et al. (2014).

As those measurement of $(D_p/D_0)_{100}$ and k_{a100} were completed, the soil was removed from the mould+plastone and then oven dried at 105°C for 24 hours to determine its dry bulk density, from which total porosity (f) and the corresponding air content (ε_{100}) can be derived.

In this case, the actual volume of the specimen was determined by filling up the mould+plastone with water. And then, mass of this water was taken as the actual volume of the specimen. The cross-sectional area of the specimen was determined by dividing the actual volume of the specimen with length of the specimen.

All the measurements above were performed for

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five times of replication, and statistical significance of the vertical vs. horizontal measurements as well as control vs. rice husk upon the measured data was examined using KaleidaGraph 4.1 software (Synergy Software 2012, USA) for Student T test analysis ($P < 0.05$).

3. Results and discussion

Fig. 2 shows a relatively strong linearity between $(D_p/D_0)_{100}$ and ε_{100} (r = 0.730) which implies that relative gas diffusivity $(D_p/D_0)_{100}$ is strongly governed by soil air content (ε_{100}). On the other hand, Fig. 3 shows a fairly strong linearity between k_{a100} and ε_{100} (r = 0.641) which supports an idea that the value of air permeability (k_{a100}) is reasonably governed by the volume of macropores ($\phi > 30$ μm) as revealed from the value of ε_{100}. These Fig. 2 and Fig. 3 further give an indication of a tendency for a higher $(D_p/D_0)_{100}$ and k_{a100}, respectively, for the vertical measurement than the horizontal measurement.

In order to make a proper comparison between the vertical and horizontal measurements, all the measured $(D_p/D_0)_{100}$ and k_{a100} were normalized to the average of ε_{100} (as shown in Table 1) using a slope of linear regression of their vertical and horizontal measurements shown in Fig 2 and Fig 3, respectively.

As shown in Table 1, vertical measurement gives a significant higher $(D_p/D_0)_{100}$ and k_{a100} than the horizontal measurement for the control, but it results conversely for the soil with rice husk. Compared to the control, soil with rice husk gives a lower $(D_p/D_0)_{100}$ and k_{a100} for the vertical measurement, but results a significantly higher $(D_p/D_0)_{100}$ and k_{a100} for the horizontal measurement.

Table 1. The normalized $(D_p/D_0)_{100}$ and k_{a100} to the average of measured ε_{100}.

	Vertical	Horizontal
$(D_p/D_0)_{100}$:		
Control	0.0180 Aa	0.0102 Ba
Rice husk	0.0162 Aa	0.0221 Bb
k_{a100}:		
Control	4.89 Aa	1.72 Ba
Rice husk	4.71 Aa	4.89 Ab

Values of $(D_p/D_0)_{100}$ or k_{a100} followed by the same capital letter (row: vertical vs. horizontal), and lowercase letter (column: control vs. rice husk), are not significantly different ($P < 0.05$)

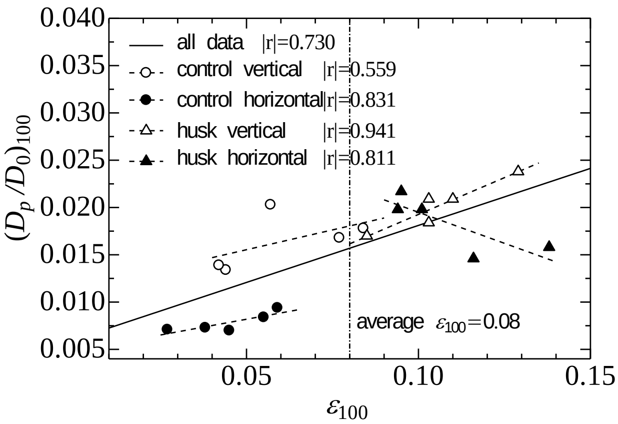

Fig. 2 ε_{100} vs. $(D_p/D_0)_{100}$

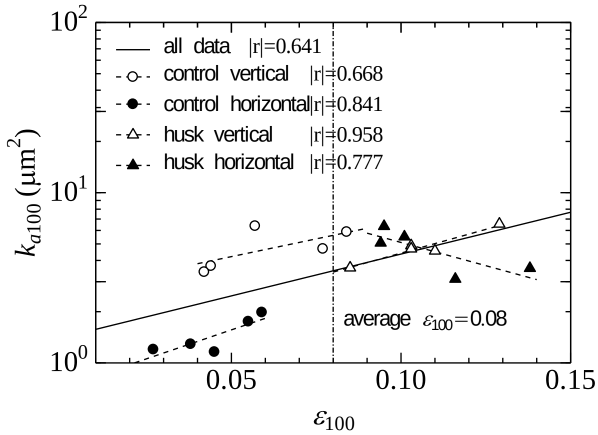

Fig. 3 ε_{100} vs. k_{a100}

4. Conclusion

Vertical measurement gives a significant higher $(D_p/D_0)_{100}$ and k_{a100} than the horizontal measurement for the control, but it results conversely for the soil with rice husk. Soil with rice husk gives a lower $(D_p/D_0)_{100}$ and k_{a100} than the control for the vertical measurement, but results a significantly higher $(D_p/D_0)_{100}$ and k_{a100} for the horizontal measurement.

References

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