Application of Time Domain Transmissiometry for Measurement of Moisture Content and Void Ratio in a Heavy Paddy Clay Soil

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Abstract: To establish a versatile farming system for paddy fields with heavy clay soils, it is essential to accurately monitor soil moisture. Although various moisture monitoring methods have been proposed, an adequate method for heavy clay soils has not been yet established because of their unique dielectric properties. Digital time domain transmission (TDT) sensors were applied for monitoring gravimetric water content (*w*) and void ratio (*e*) in a paddy soil. While during the initial rice growth stage the TDT sensors yielded excellent results, some problems were experienced when the soil dehydrated and shrinkage cracks developed in close vicinity of the sensors. The estimated from *w* decreased gradually and irreversibly despite repeated rainfall and irrigation. Although more detailed studies regarding optimal sensor placement are required, presented results demonstrate the potential applicability of TDT for monitoring *w* and *e* and related geotechnical properties of heavy clay soils.

Keywords: Time domain transmissiometry (TDT), TDT waveform, Heavy clay, Water content, Void ratio, Monitoring

1. Research background

Photo1 A lowland paddy field.

Technical problem in field studies

An adequate monitoring method of soil moisture for heavy clay soils has not been yet established.

The aim of present study is to establish a versatile farming system using TDT soil moisture sensor for paddy fields with heavy clay soils.

2. Experimental methods

1. Laboratory experiments

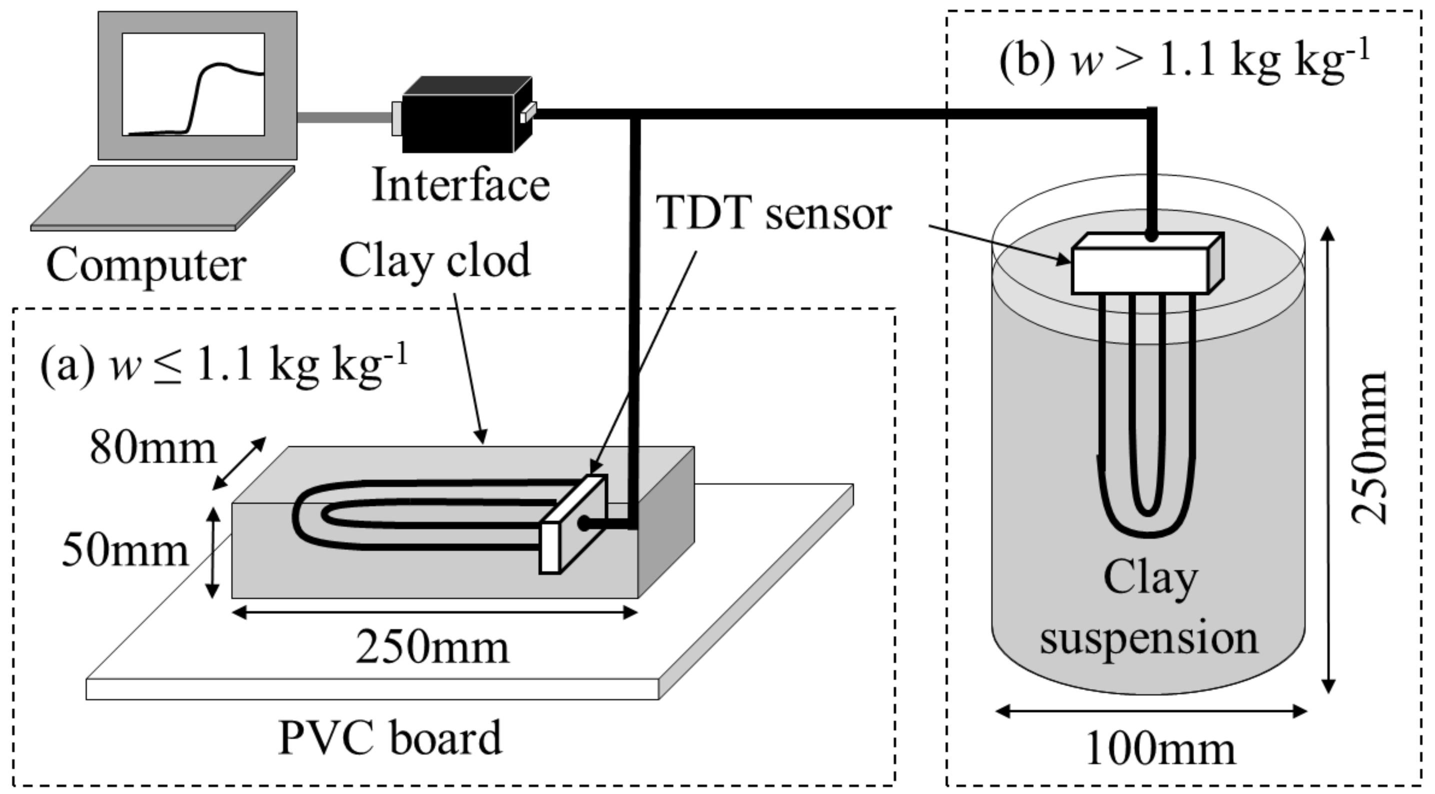

Fig.1 Schematic of laboratory experiments.

- Materials under test: Ariake clay-distilled water mixtures with different moisture content
- Gravimetric water content (w): 0.49 ~ 2.21 kg kg^{-1}
- Soil texture: Sand 5.6 %, Silt 37.4 %, Clay 57.0 %
- Measured data sets: TDT waveforms, Apparent permittivity (ε_{TDT})

2. Field experiment

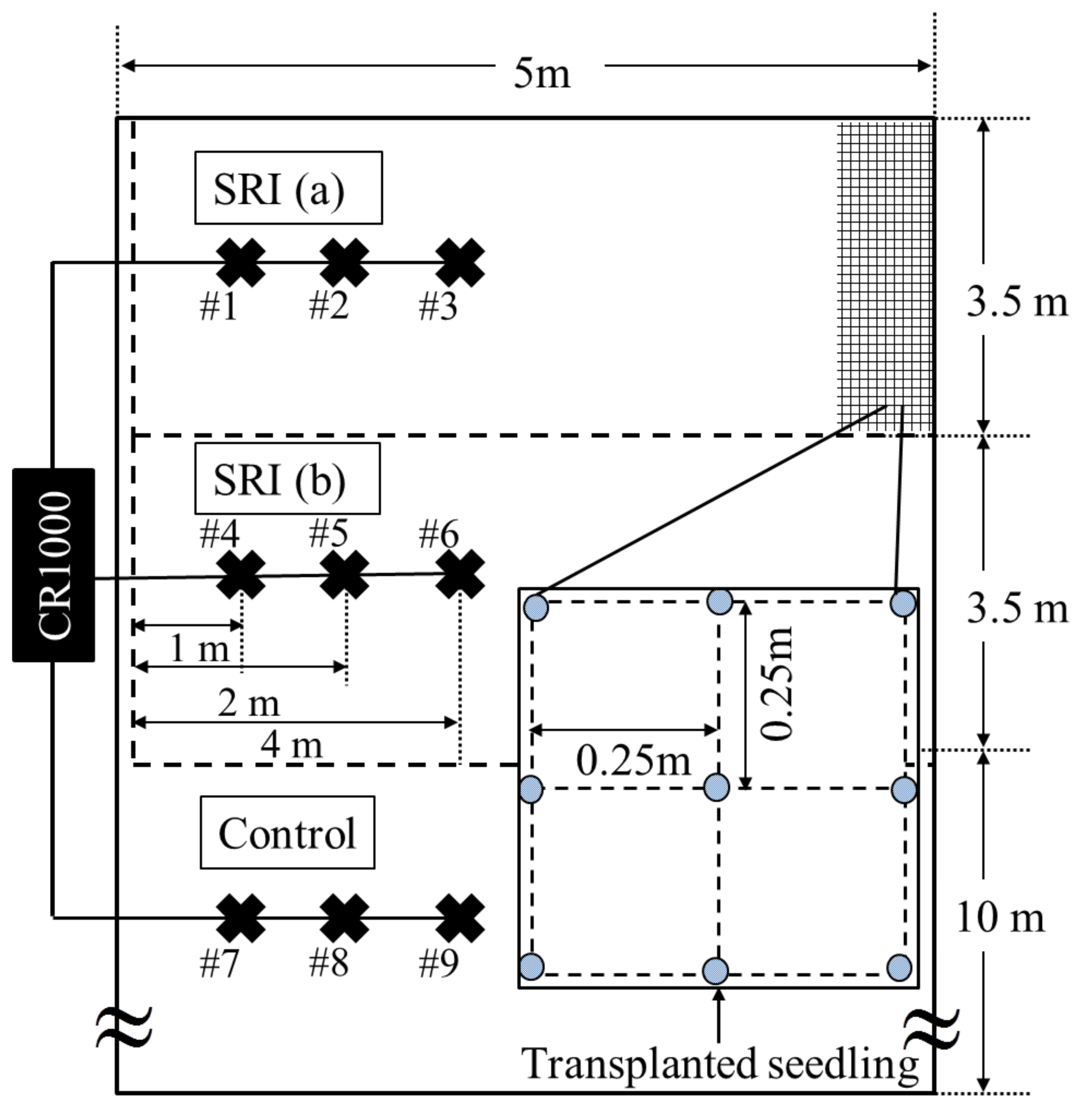

Fig.2 Schematic of an experimental site.

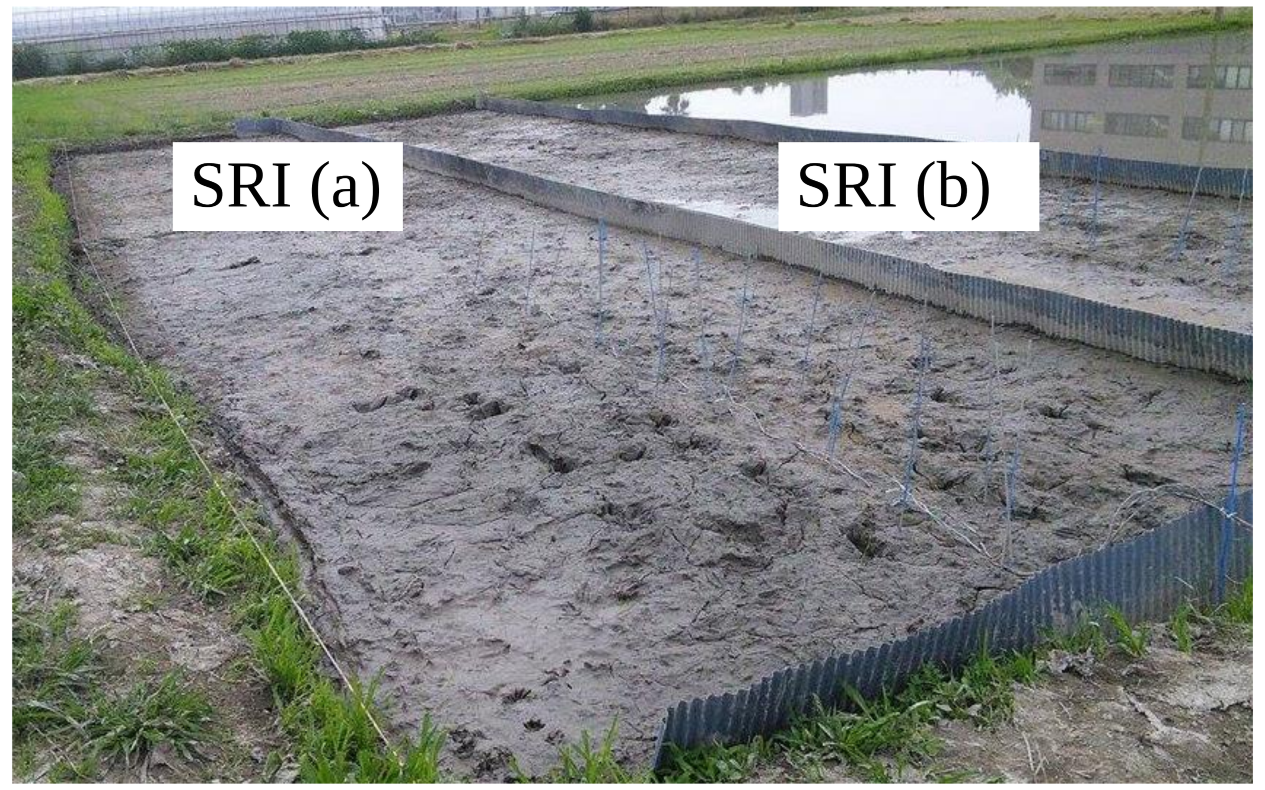

Photo2 Experimental paddy fields.

- Experimental site: SRI paddy fields with heavy clay soil (3.5 m × 5 m)
- Measured data sets: ε_{TDT}, Precipitation

3. Laboratory experiment

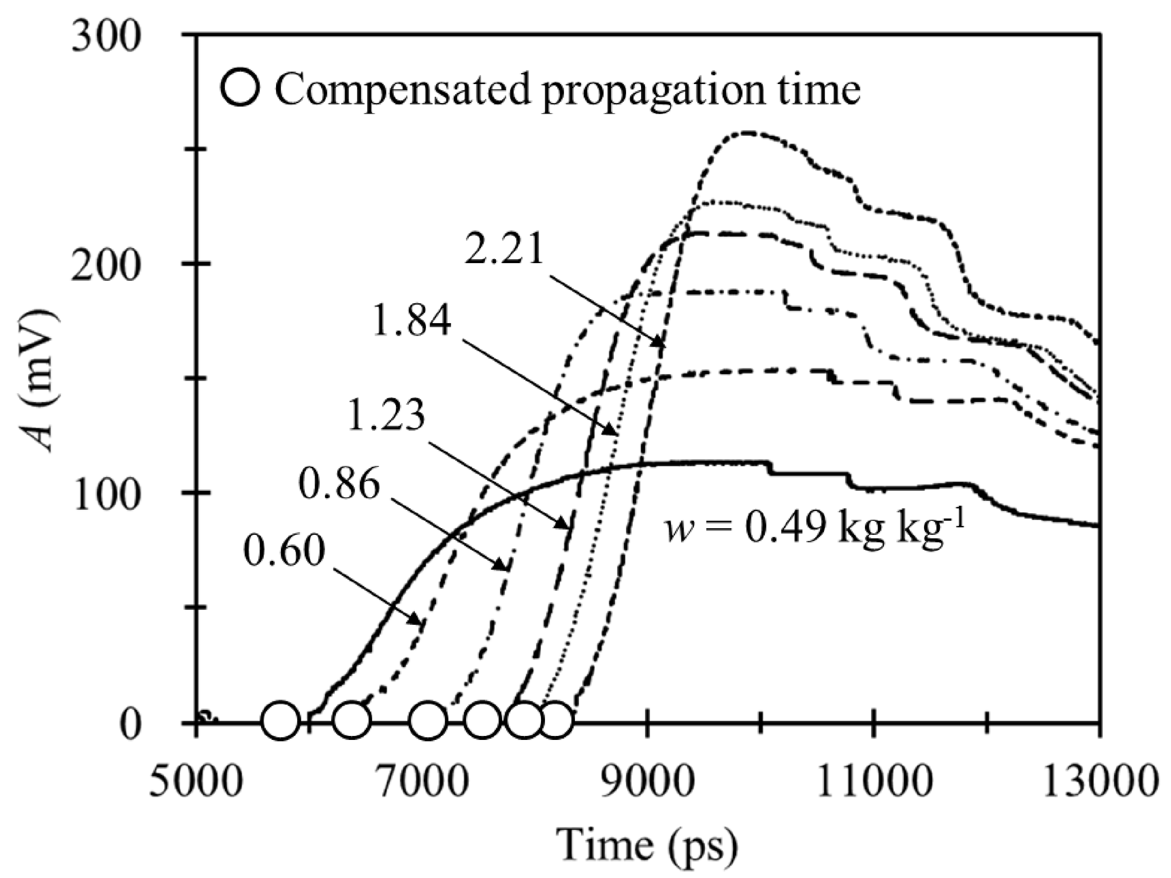

Fig.3 TDT waveforms.

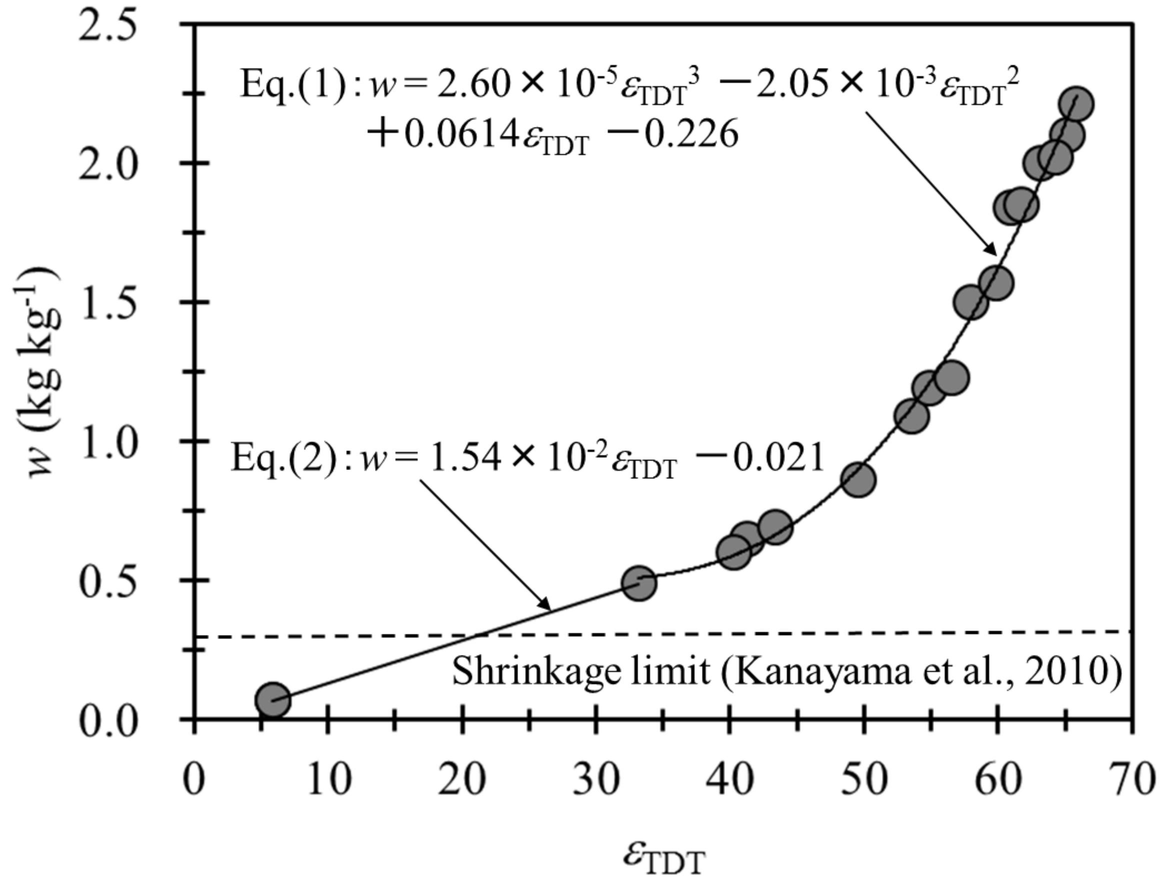

Fig.4 Apparent permittivity(ε_{TDT}) vs. gravimetric water content (w).

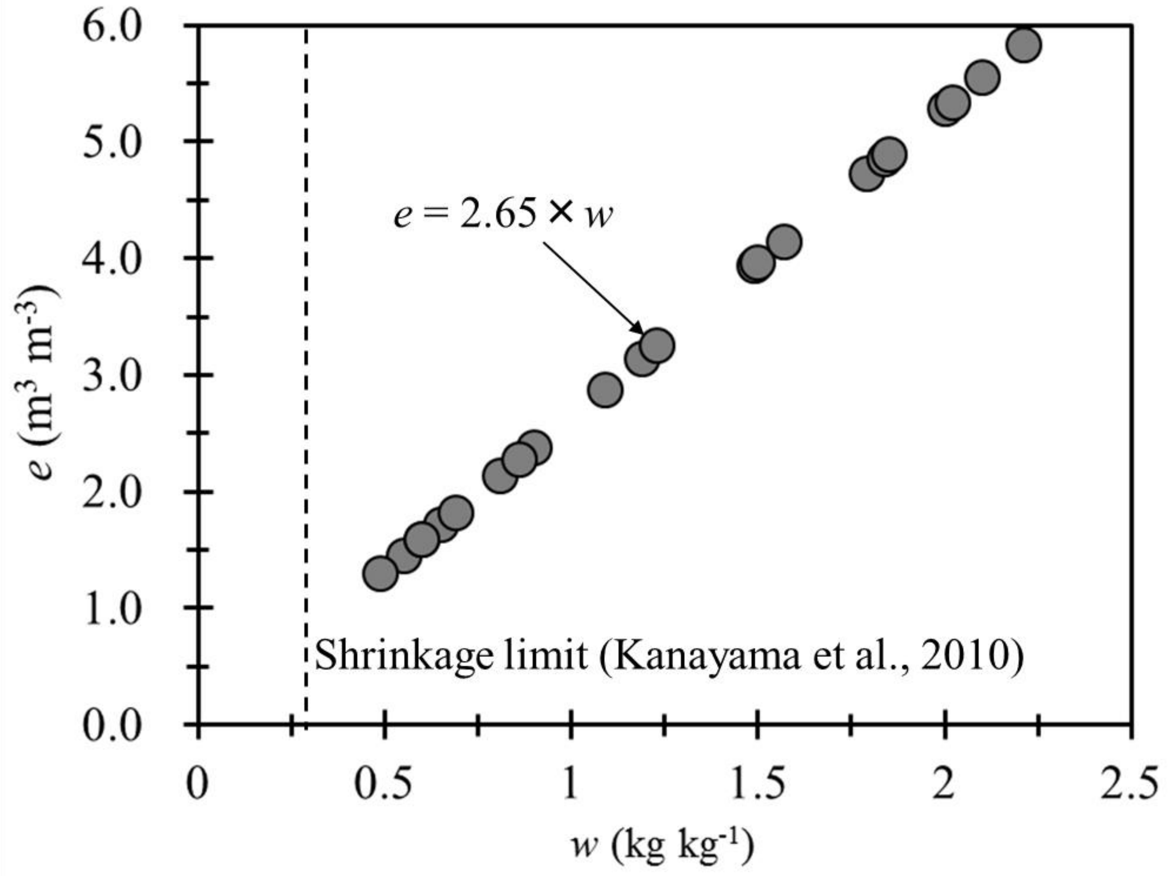

Fig.5 Gravimetric water content (w) vs. void ratio (e).

4. Field experiment

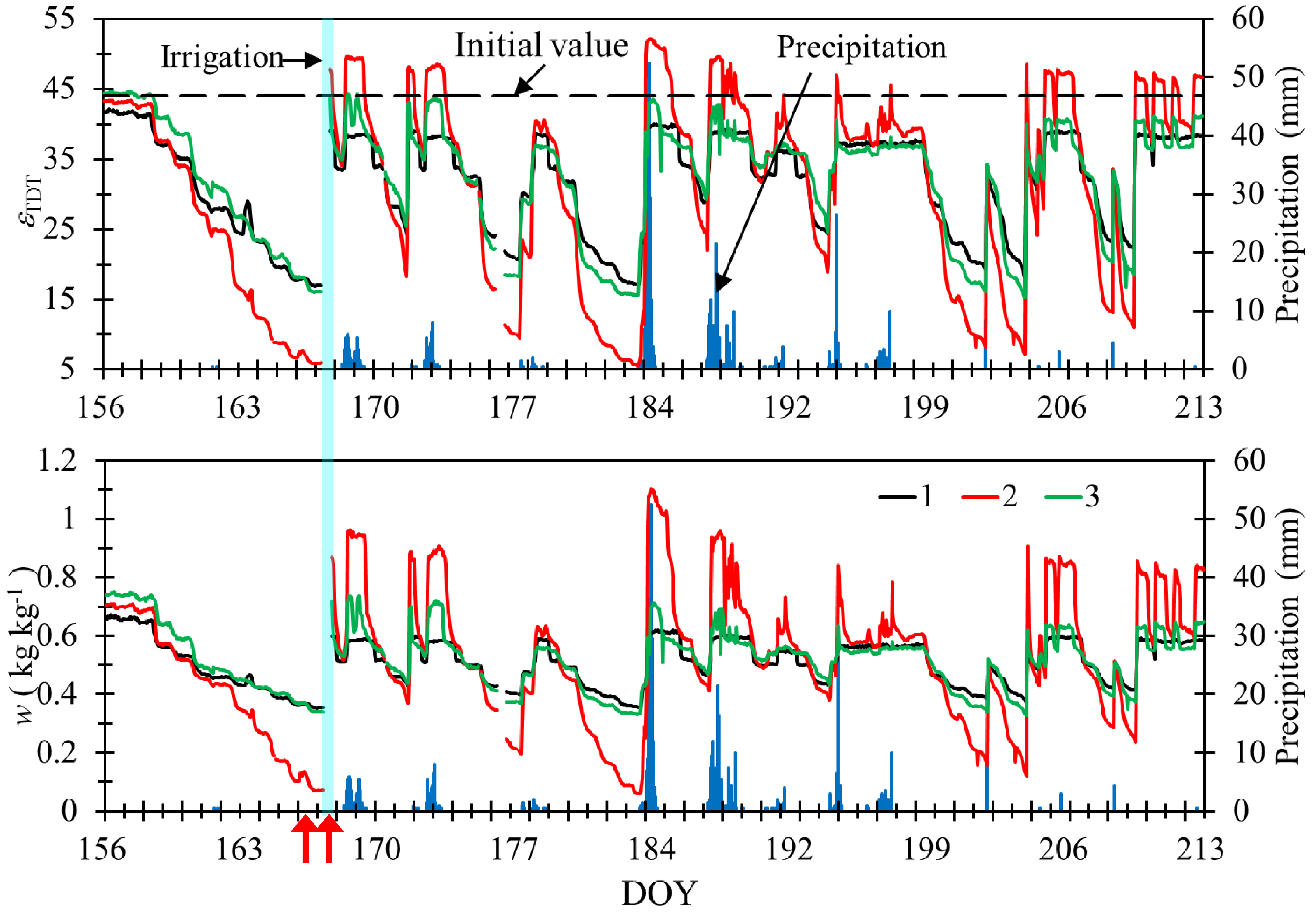

Fig.6 Changes in apparent permittivity obtained (ε_{TDT}) and gravimetric water content (w) .

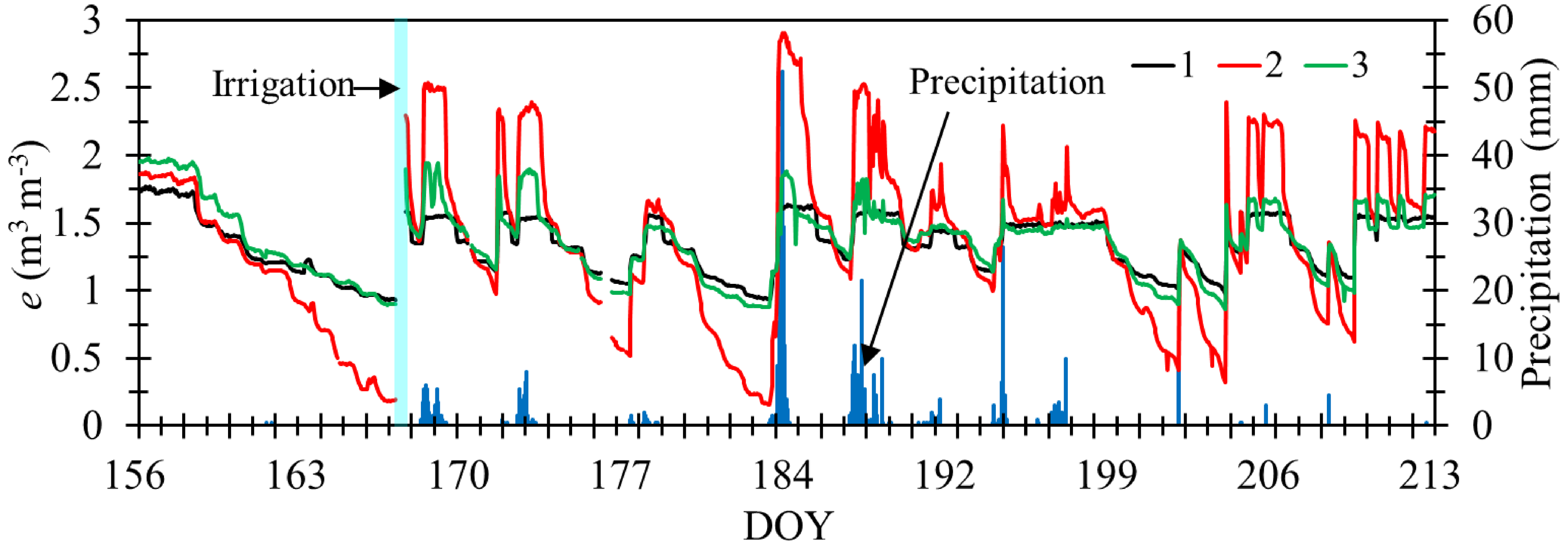

Fig.7 Changes in void ratio (e).

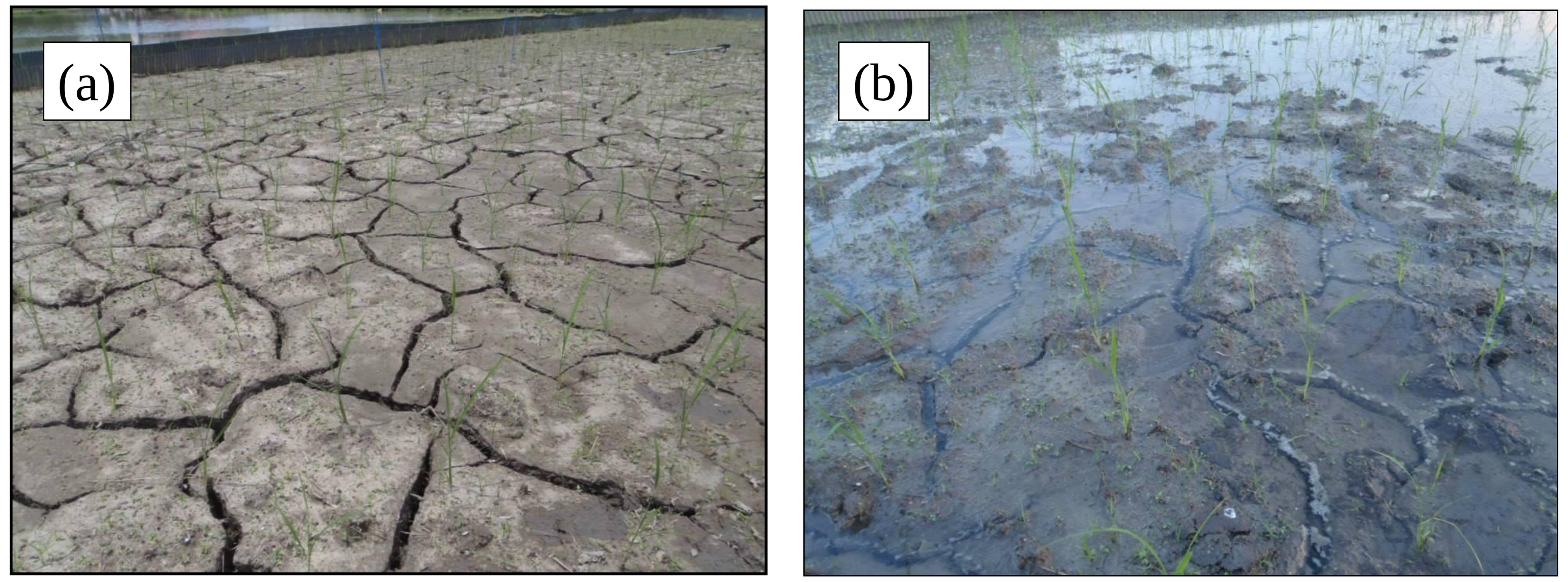

Photo3 A SRI paddy field ((a) dry condition, 166 day (b) flooded condition, 167 day).

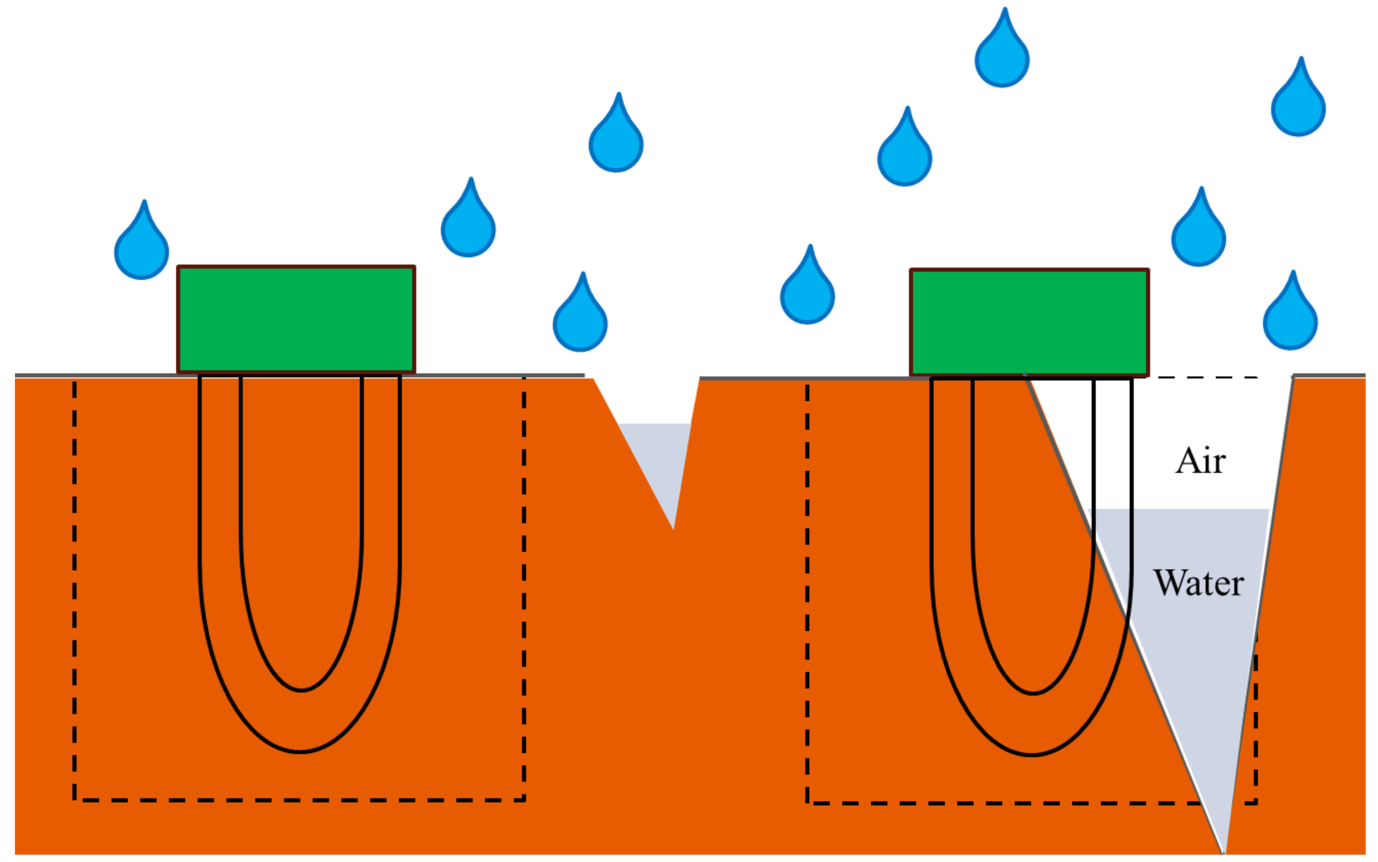

Fig.8 Schematic of shrinkage cracks developed in close vicinity of the sensors.

5. Conclusion

Although more detailed studies regarding optimal sensor placement are required, presented results demonstrate the potential applicability of TDT for monitoring w and e and related geotechnical properties of heavy clay soils.

Reference: Kanayama et al. (2010): Degradation of soil-channel slope in ariake sea coastal area, Proceedings of the annual meeting of the Japanese society of irrigation, drainage and rural engineering, 384-385.