Potential measurement as a method for monitoring the soil chemical environment

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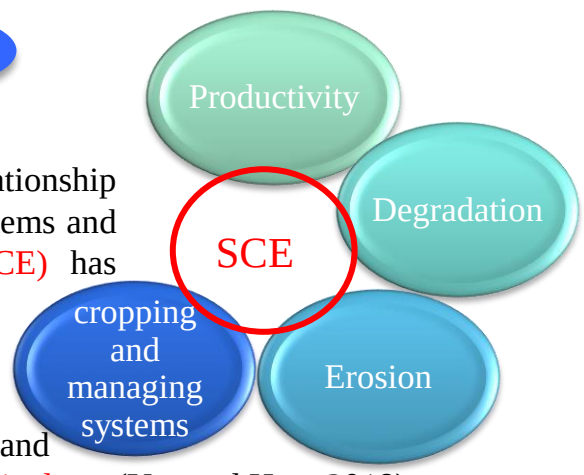
Background / Aim

Background :

Over the last few decades, the relationship between cropping and managing systems and the soil chemical environment (SCE) has been discussed.



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The understanding of SCE → Sustainable crop production and environmentally friendly agriculture (Yan and Hou, 2018)

pH, organic matter contents, phosphorus availability, and cation exchange capacity have been widely used as indices for evaluating SCE.

However, their measurements cannot be conducted continuously, thus changes in the SCE over time are underdetermined.

➡ Potential measurement (our proposal)

⇩ Nagama et al., 2018

Water potential measurement can describe changes over time in the water quality at the sea floor.

→ However, no report related to monitoring SCE

Aim of this study :

Proposes a method for measuring soil ORP and examines the method's validity in representing changes in SCE due to soil reduction, bacteria activation, and soil oxidation. This was done by continued potential measurement to determine changes in the soil ORP of paddy soil.

Materials / Methods

Materials:

Paddy soil: Approximately 150 mm of the surface soil collected from a rice field (Ebina, Kanagawa, Japan).

Potassium sulfate: readily available product

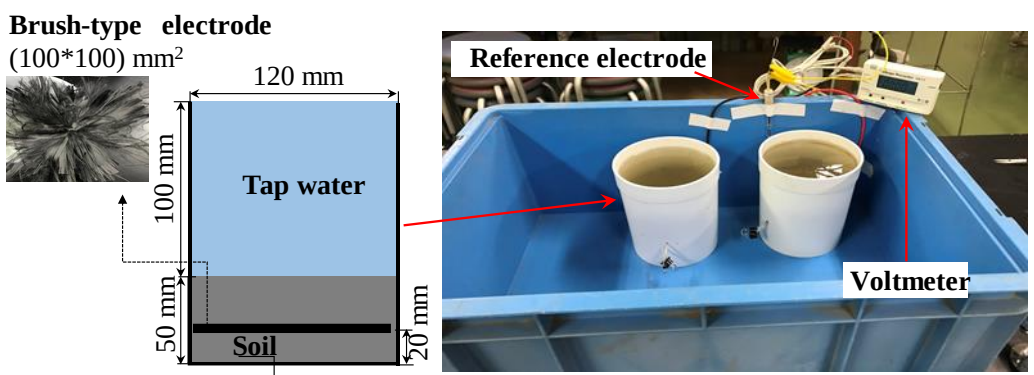
Cow manure compost: readily available product

(The paddy soil was mixed with cow manure compost, or potassium sulfate to ensure differences in the SCE.)

Electrode: Carbon cloth (News Company, PL200-E), which was heated at 500ºC for 1 h prior to use Nagatsu et al. (2014). The heated carbon cloth with a width of 100 mm and a length of 100 mm was separated into fibers to form a brush-type electrode.

Procedures and Measurements:

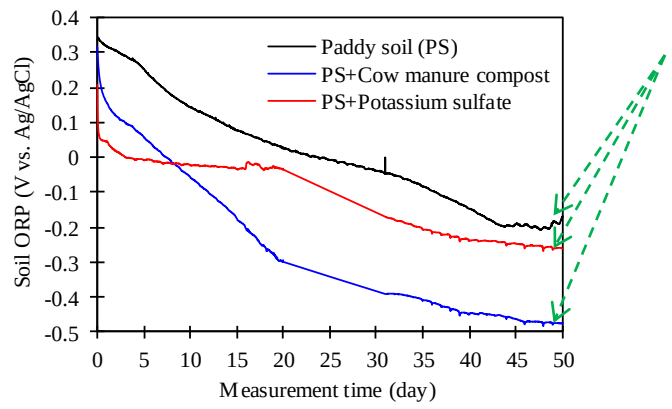
- The bottle (diameter: 120 mm, height: 150 mm) was filled with paddy soil to a depth of 20 mm, and a brush-type carbon electrode was placed on the soil layer. Then, another soil layer at a depth of 30 mm was placed on the electrode (see Figure below).
- The electrode in the soil layer was connected to a reference electrode (Toyo Co., TRE-7) for measuring the electrode potential. The potential was recorded automatically every 15 min by a voltmeter (T&D Corp., VR-71).



Case 1: paddy soil, **Case 2**: Cow manure compost-paddy soil mixture, **Case 3**: potassium sulfate-paddy soil mixture

Results / Discussion

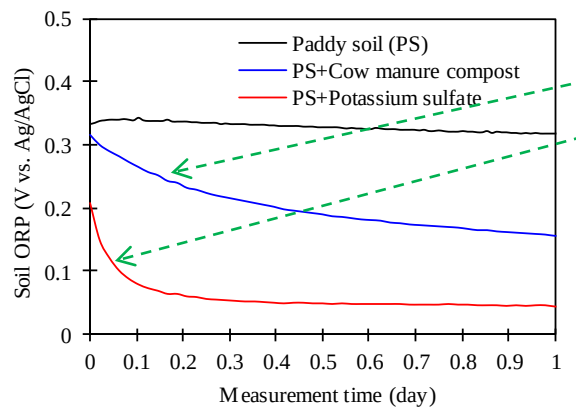
Potential Measurement for Representing Soil Reduction



- A difference in soil ORP was observed.
- Different redox reactions result in a difference in soil ORP (Liesack et al., 2000)

Potential measurement is useful for understanding changes in SCE due to redox reactions in soils.

Potential Measurement for Representing Microbial Activation in Soils



Compared with paddy soil

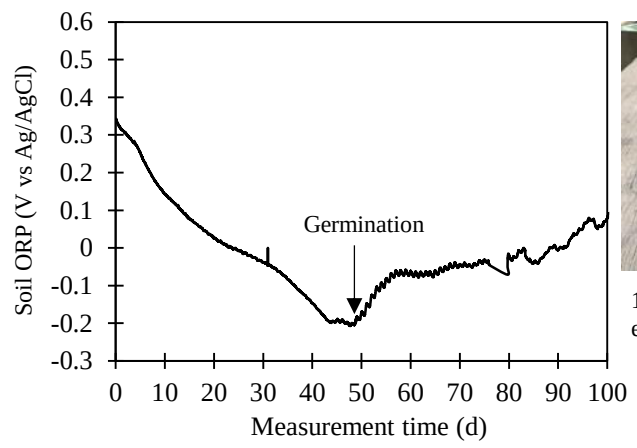
- A large decrease
- An even larger decrease

These trends depend on the redox reactions occurring at the electrode and possible potential losses due to electron transfer at the electrode surface.

- Large changes will be observed when the redox reaction varies from one to another redox couple.
  → Iron reduction in the paddy soil alone to sulfate reduction
- Microbial activation minimizes potential loss (Wang et al. 2009)
  → Equilibrium potential will be obtained in a short time

Changes in the redox couple and the benefits of microbial activation in soil can be understood through potential measurement.

Potential Measurement for Representing Soil Oxidation



170 days after the experiment started

- Germination was confirmed on day 50
- soil ORP started to increase on day 50

→ Soil oxidation owing to the oxygen supply from the overlying water

Potential measurement may also predict soil oxygen levels

Summary

It was found out that the proposed method, i.e., potential measurement, had high accuracy (with a variance of 1.33%) for representing SCE. A difference in equilibrium soil ORP was observed when mixing different fertilizers with paddy soil, indicating that redox reactions in soils can be predicted through potential measurement. In addition, different trends in decreasing soil ORP were observed, suggesting that chemical and biological reactions in soil can be understood from potential measurement. Finally, soil ORP started to increase on day 50 because of soil oxidation, indicating that potential measurement can predict soil oxygen supply that causes soil oxidation.

References

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