Enhanced performance of soil microbial fuel cell by earthworms

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Absract

Currently, energy supply source from fossil fuels have issues and demand for renewable and sustainable energy is increasing. Soil microbial fuel cells (SMFCs) are electricity generation devices that using microbes in the soil. These are expected as an application to produce sustainable energy. But the problem with this device is that the obtained power is low. Here, we focused on soil ecosystems, specifically the earthworms. Earthworms were added to SMFC and the SMFC performances were compared to SMFC with and without earthworms. As a results, the power density increased and the internal resistance decreased. In addtion, promotion of plant growth on soil of SMFC to which earthworm was added was showed.

Soil microbial fuel cell (SMFC)

Soil microbial fuel cells (SMFCs) are devices that using microorganisms in the soil as biocatalysts to directly convert chemical energy to electricity (Fig. 1A). The device can generate power only with soil and two electrodes. The LED is able to light using this device (Fig. 1B).

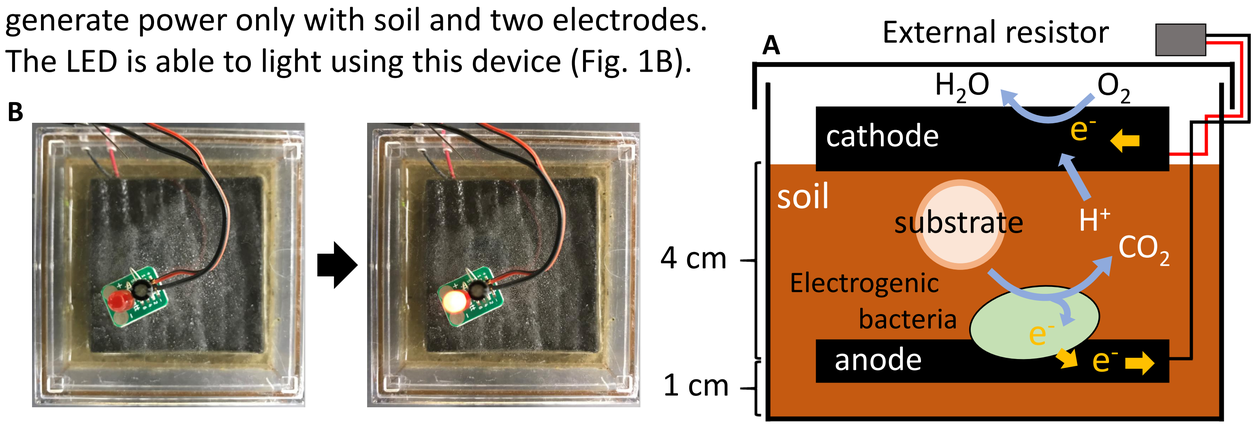


Fig. 1. Schematic expression of SMFC (A) and lighting LED by SMFC (B).

Earthworm

Earthworms are annelid and distribute in the soil around the world and degrade fallen leaves or plant litter. There have been reports that they are useful for agriculture.



Fig. 2. Earthworm.

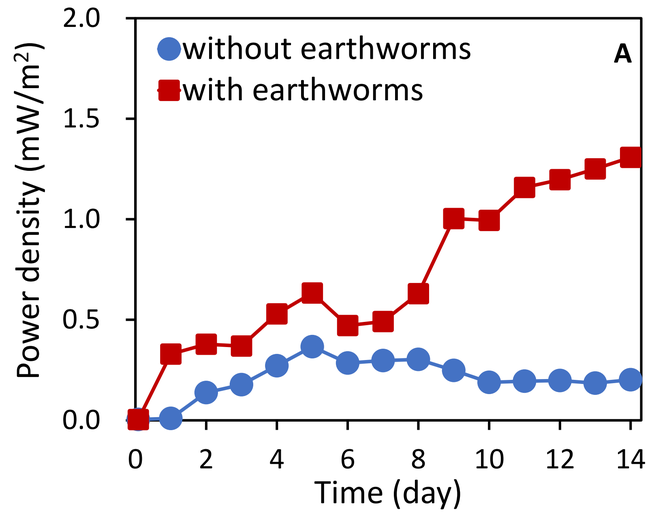
The effect of earthworms

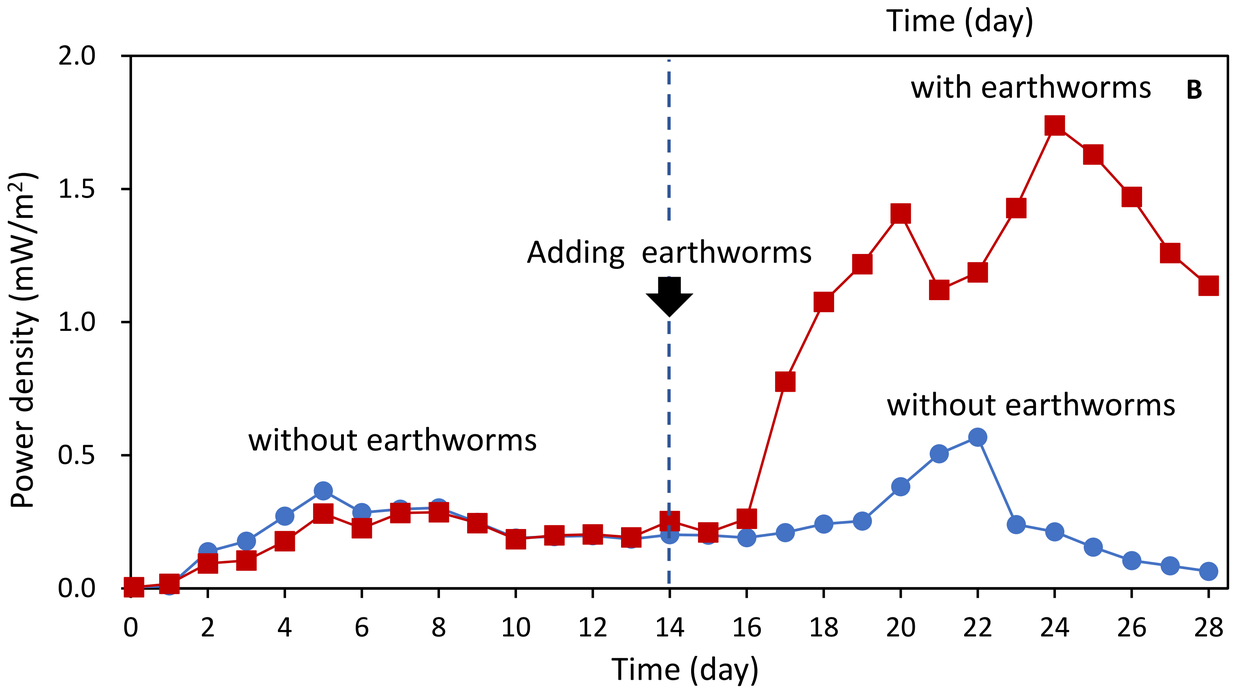
- Plant growth promotion
- Inhibition of pathogen
- Soil improvement
- Enhance of microbial activity in the soil

Experiment 1 : Comparison with the SMFC with and without earthworms.

The power of SMFCs with and without earthworms were compared. SMFCs with earthworms showed higher power than that of SMFCs without them.

To examine whether the effect on the power is caused by earthworms, two SMFCs were set up and operated for 2 weeks. After confirming the power-similarity of the SMFCs, earthworms were added to one of them on the 14th day, shown by the vertical arrow in Fig. 2. On the third day after the earthworms were added, a rise in power was observed.





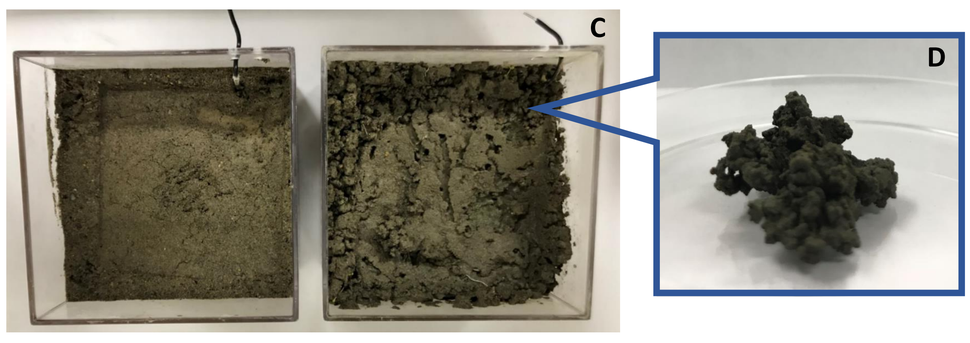


Fig. 3. Power density of the SMFC with or without earthworms (A). Effect of adding earthworms to SMFC in operation (B). Structure of soil surface in SMFC with and without earthworms (C). Formed aggregate structure (D).

Experiment 2 : Effect of the number of earthworms on the SMFC.

SMFC with 1, 5 or 10 earthworms and one without earthworms were constructed and the voltage was measured for 30 days (Fig. 3A). All SMFCs with earthworms showed higher power density than the SMFC without earthworms. After 30 days, the polarization curve and power curve were calculated and compared (Fig. 3B, C, D).

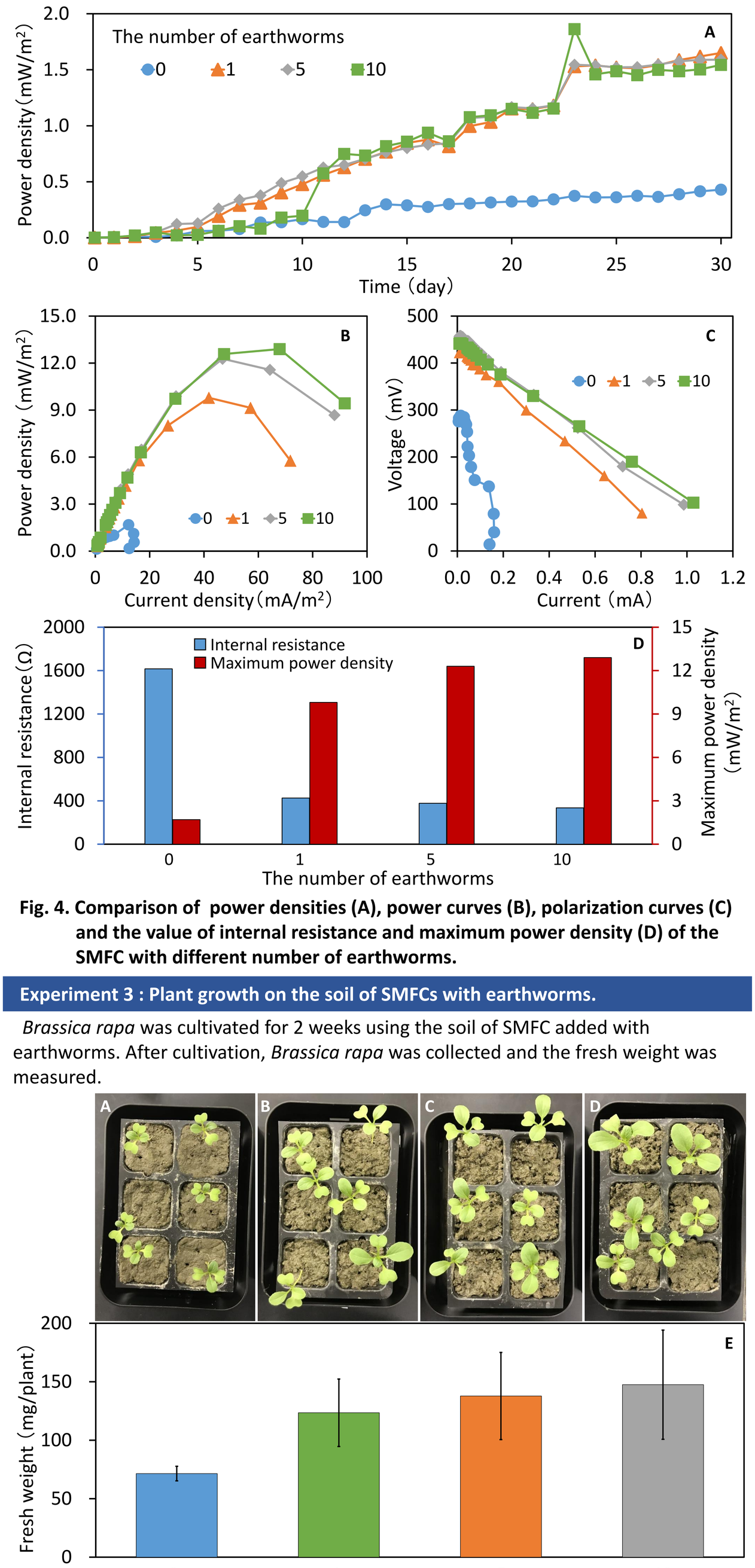


Fig. 4. Comparison of power densities (A), power curves (B), polarization curves (C) and the value of internal resistance and maximum power density (D) of the SMFC with different number of earthworms.

Experiment 3 : Plant growth on the soil of SMFCs with earthworms.

Brassica rapa was cultivated for 2 weeks using the soil of SMFC added with earthworms. After cultivation, *Brassica rapa* was collected and the fresh weight was measured.

Fig. 5. Fresh weight of *Brassica rapa* cultivated in the soil with earthworms.

Conclusion

- The power density obtained from SMFC increased by adding earthworms.
- As the number of earthworms increased, the maximum power densities increased and the internal resistances decreased.
- In the soil of SMFC added with earthworms, promotion of plant growth was observed.

It was suggested that adding earthworms to SMFC enhances power generation efficiency and the soil after power generation can be effectively used agriculturally.