Evaluating the 2-D Distribution of Volumetric Water Content and Electrical Conductivity with Cloud-Based Drip Fertigation System.

Poster # 1301

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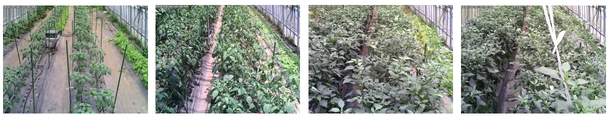
Introduction

Due to the accident of the Fukushima Daiichi Nuclear Power Plant in 2011, surrounding farms were contaminated with radioactive cesium (Cs). Contaminated but fertile surface soil was successfully decontaminated by replacing a less-fertile sandy soil, implying that crop productivity might be hindered. We thought that applying a fertilization irrigation technology could overcome the problem in crop production in a less-fertile soil. In this research, we evaluated the distribution of water and electrical conductivity in the less-fertile soil growing bell peppers in a greenhouse. A cloud-based drip fertigation system, ZeRo.agri (Routrek Networks, Inc., Kawasaki, Japan), determined the quantity of water for drip irrigation once an hour based on soil water content and solar irradiance using a pyranometer outside the greenhouse.



Materials & Methods

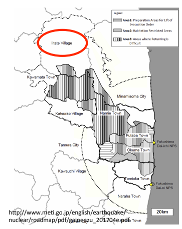


Fig. 1 Experimental measurement site.

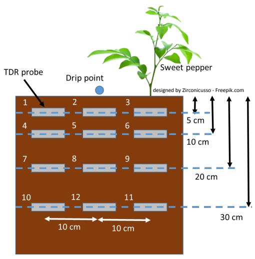


Fig. 2 Schematic of TDR-probe and TC.

- Site : Iitate Vilage, Fukushima, Japan (Fig. 1)
- Experimental period: 6th Jun. – 14th Nov. (2016)
- Cultivated Crop: Bell Peppers (TAKII & CO., LTD)
- Control the amount of irrigation: ZeRo.agri

- To monitor the time series of 2-D distribution of volumetric water content (θ) and electrical conductivity (EC) in soil, time domain reflectometry (TDR) probes were horizontally installed, perpendicular to a drip line, at 5, 10, 20, and 30 cm below the soil surface (Fig. 2).

- Volumetric water content (θ) and EC were calculated below equations:

$$\theta = 4.53\times10^{-2} + 2.31\times10^{-2}\varepsilon - 4.0\times10^{-4}\varepsilon^2$$

$$EC_w = \frac{\varepsilon_w EC_b}{\varepsilon_b - \varepsilon_{EC_b=0}} \qquad EC_{w25} = \begin{cases} EC_w\left(1.00 + \frac{(25-T)}{49.7} + \frac{(25-T)^2}{3728}\right) & 20 \le T \le 47\ ^{o}C \\ EC_w\left(1.00 + \frac{(25-T)}{53.3} + \frac{(25-T)^2}{1667}\right) & 3 \le T \le 28\ ^{o}C \end{cases}$$

ε: bulk dielectric constant by TDR measurement
EC_b: bulk EC by TDR measurement
EC_w: EC of soil solution
T: Temperature (°C)
EC_{w25}: EC of soil solution at 25°C

- Type-T thermocouple junctions (TC) for measuring soil temperature were installed at the same location as the TDR probes.

Results

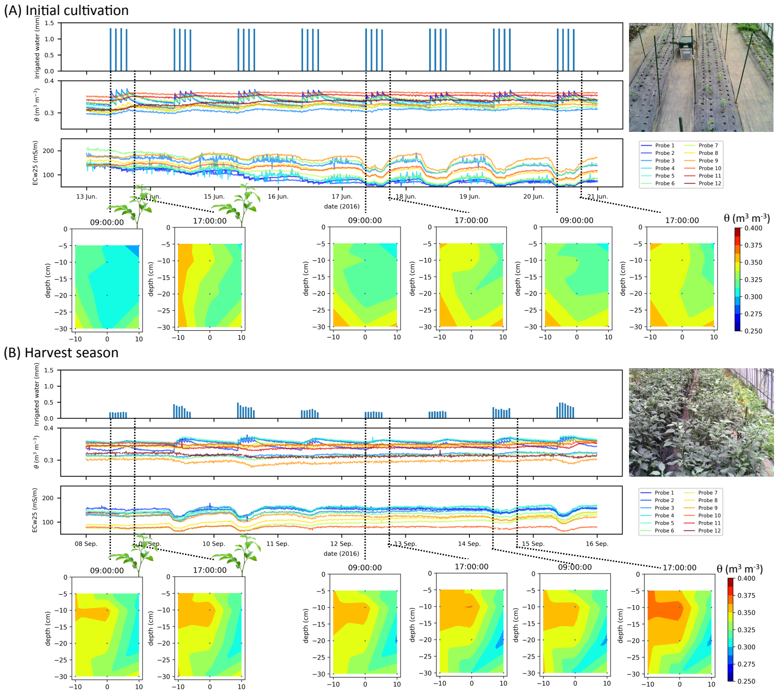


Fig. 3 Time series variation of θ, EC_{w25}, and irrigated water in (A) initial cultivation and (B) harvest Season.

Volumetric Water Content

- θ increased after the time of irrigation at the soil surface, but bottom θ were almost not change.
- θ changes were small in plant side (2-D distribution).

Water Balance (Δθ)

- Δθ defined as the difference average θ (average of 12 probes) between 9 a.m. and 5 p.m

$$\Delta\theta = \theta_{average(17:00)} - \theta_{average(9:00)}$$

- Values of Δθ became smaller as time proceeded because the ZeRo.agri system gradually adjusted the amount of irrigation water applied (Fig. 4).

Electrical Conductivity

- EC_{w25} tended to decrease during the daytime.
- EC_{w25} hardly changes on the day when time series variation of θ was small.

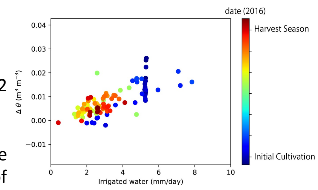


Fig. 4 Irrigated water vs. Water balance Δθ.

References: U.S. Salinity Laboratory Staff (1954). Diagnosis and improvement of saline and alkali soils. Agriculture Handbook no. 60. U.S.D.A., U.S. Government Printing Office, Washington, DC.

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