Evapotranspiration of Bell Pepper Grown with Cloud-Based Fertigation in Greenhouse

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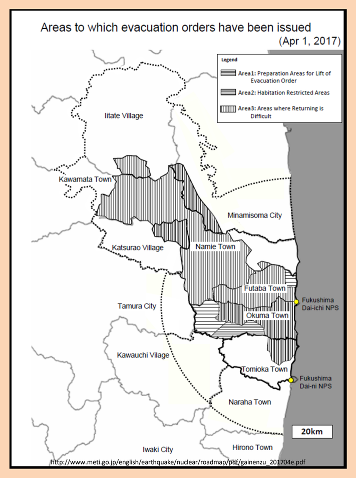
Introduction

A fertile surface layer of farmland was decontaminated and replaced by non-fertile soil in Fukushima since the accident of Fukushima Daiichi Nuclear Power Plant in 2011. We reported that liquid fertilizer was applied suitably as a result of the evaluation of changes in the volumetric water content in soil where was conducted a commercially-available cloud-based fertigation system (CBFS). In this study, amount of irrigated water of bell pepper growth with CBFS were evaluated with the evapotranspiration, stem flow, and the volumetric water content.



Materials and methods

Experimental site: Dry field at greenhouse in Iitate village, Fukushima in northern Japan

Experimental period: 9 June to 10 August, 2017

Soil texture: Sandy clay loam (sand: silt: clay= 60: 25: 15)

Fertigation system: ZeRo. agri (Routrek Networks Inc., Japan)

Dripline: Uniram 17 (NETAFIM, Israel)

Grown crop: Bell pepper

ZeRo. agri

Evapotranspiration (ET_p)

Penman-Monteith method (Campbell, 1985)

Air temperature, relative humidity, wind velocity, net radiation at z=2 m and soil heat flux at 5 cm below the soil surface were measured.

Environmental condition sensors

Volumetric water content (θ_w)

$$\theta_w = 4.53\times10^{-2} + 2.31\times10^{-2}\varepsilon_b - 4.00\times10^{-4}\varepsilon_b^2$$

ε_b is dielectric permittivity.

Dielectric permittivity: Time Domain Reflectometry(TDR)

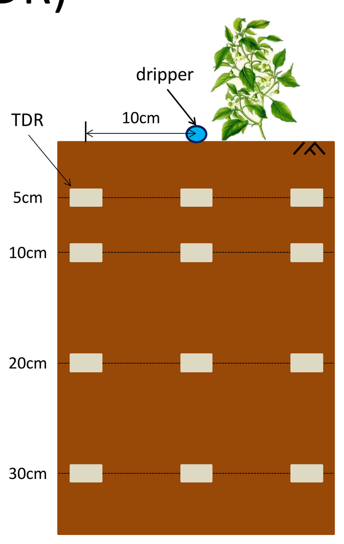
Stem flow (F_{sm} and F_{sl})

Stem flow gauge (Sakuratani, 1981)

Stem flow was measured from 6 to 8 August.

stem flow by length F_{sl} (mm 30 min^{-1}) was given:

$$F_{sl} = \frac{F_{sm}}{\rho_w \pi r_e^2} \quad (1)$$



Stem flow gauge

F_{sm} (g 30 min^{-1}) which was measured is stem flow by mass, ρ_w (=10^{-3} g mm^{-3}) is density of liquid water, and r_e (mm) is effective radius.

Conclusion

We evaluated the irrigated water with CBFS. Penman-Monteith method is applicable in a green house. This cloud-based fertigation system could irrigate suitable amount of liquid fertilizer after expected required water uptake of bell pepper.

Reference

Campbell G. S. (1985): Soil physics with BASIC. Elsevier, NY, USA, pp.150.

Sakuratani T. (1981): A heat balance method for measuring water flux in the stem of intact plants. J. Agr. Met., 37(1): 9-17

Acknowledgement

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Results and discussion

ET_p vs F_{sm}

- Trend of ET_p and F_{sm} agreed well with photon flux (Fig. 1).
- ET_p and F_{sm} had logarithmic relationship and were separated according to eq. (2) (Fig. 2).

$$P_t > 100 \ or \ (P_{t-1} - P_t > 40 \ and \ P_{t-1} > 89) \quad (2)$$

P_t and P_{t-1} are photon flux at t and t-1, respectively.

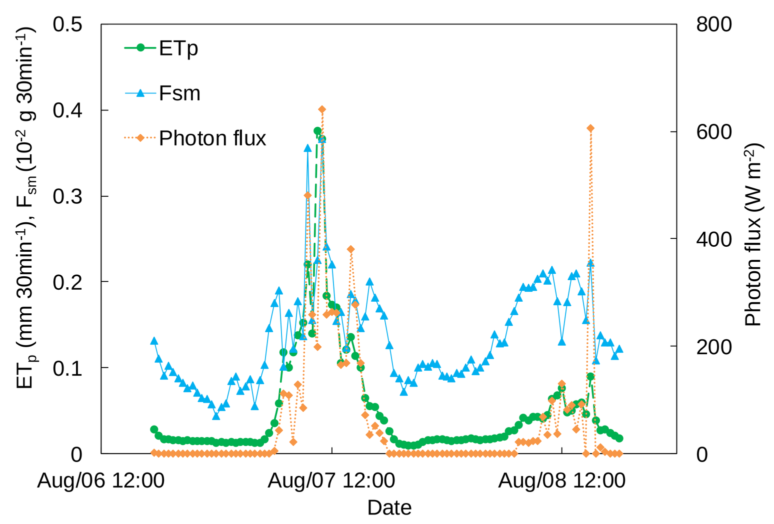

Fig. 1 daily changes in ET_p and F_{sm} and photon flux

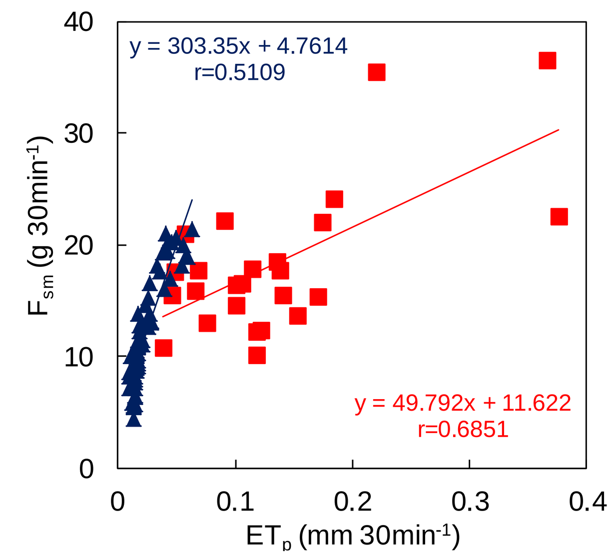

Fig. 2 Comparison of ET_p and Fsm F_{sm}

Effective area

- θ_w was high underneath the emitter (Fig. 3).
- θ_w underneath bell pepper was low: consumed soil water underneath itself(Fig. 3).
- r_e around bell pepper based on ET_p and eq. (1) were whole day: 210.96 mm, satisfied eq. (2): 189.27 mm, and not satisfied eq. (2): 380.90mm (Fig. 4).
- According to eq. (2), ET_p and F_{sl} agreed well (Fig. 5).
- r_e based on distribution of θ_w is smaller than r_e based on ET_p and F_{sm}.
- Penman-Monteith method is applicable in a green house.

ET_p vs irrigated water (Fig. 6)

ET_p and irrigated water agreed well after 20 June.

Since vegetation did not sufficiently cover, ET_p was not available before 20 June.

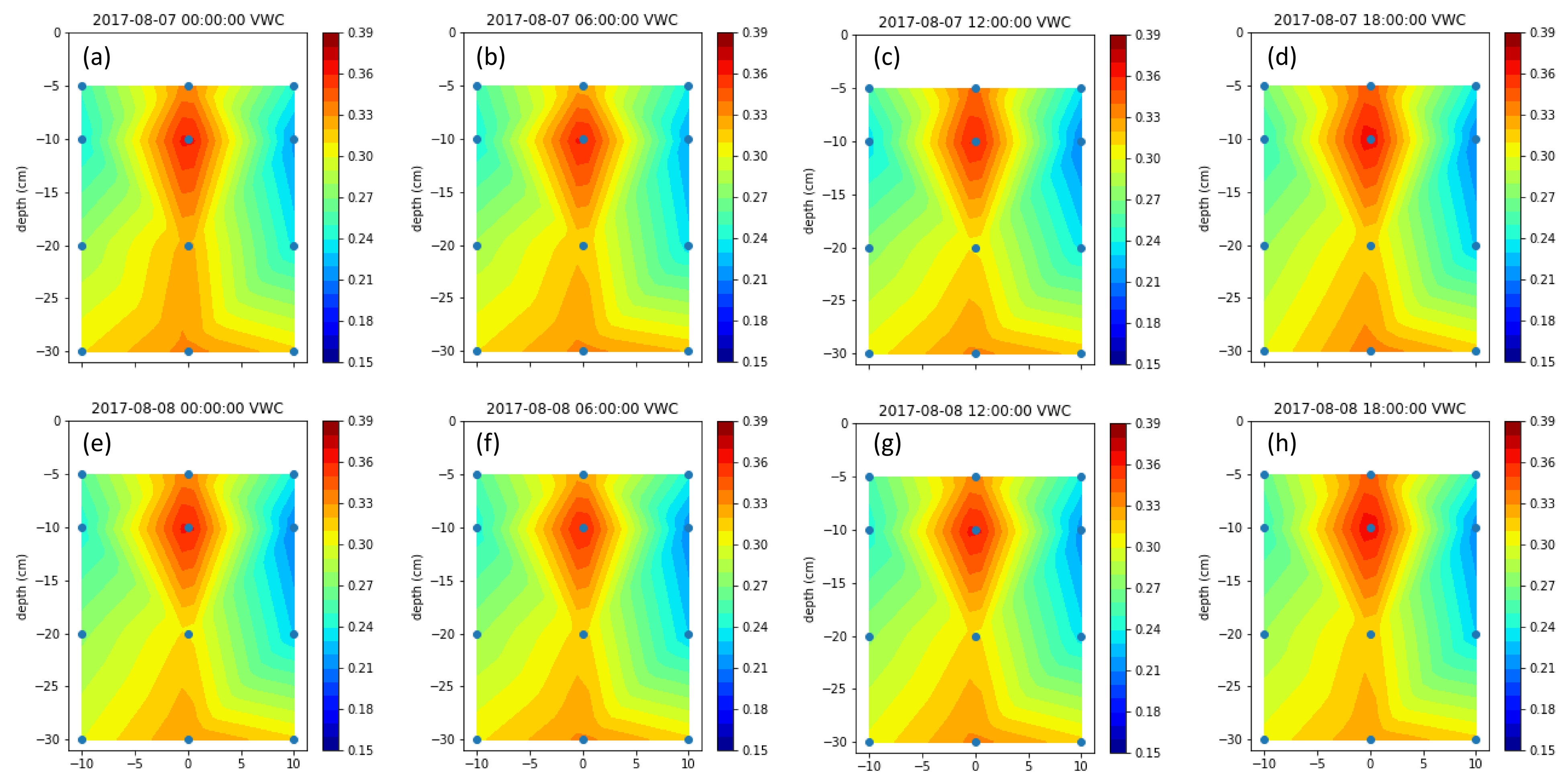

Fig. 3 Distribution of volumetric water content in vertical soil on 7 August (a) 0am, (b) 6am, (c) 0pm, and (d) 6pm and 8 August (e) 0am, (f) 6am, (g) 0pm, and (h) 6pm.

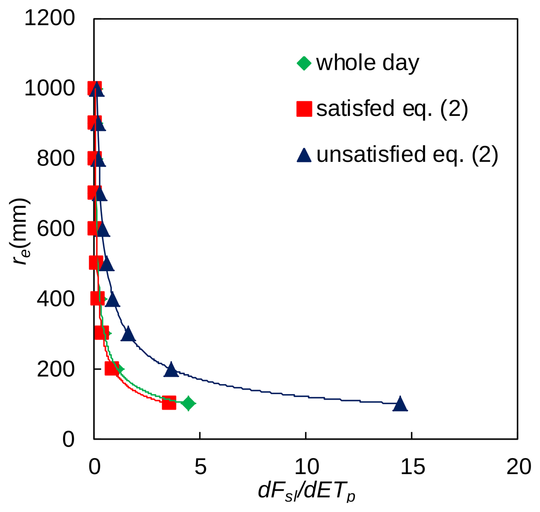

Fig. 4 Comparison of dF_{sl}/dET_p and effective radius

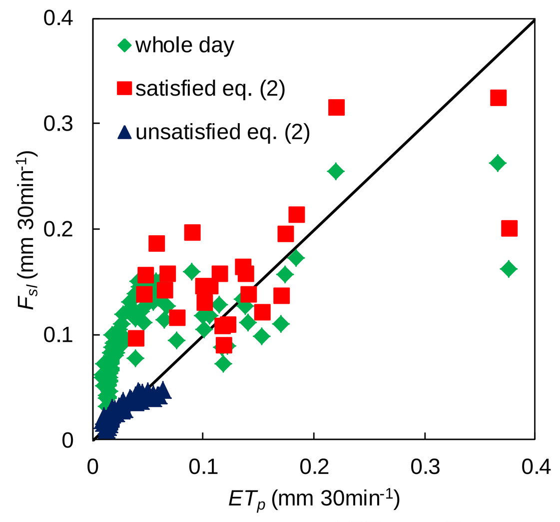

Fig. 5 Comparison of ET_p and F_{sl}

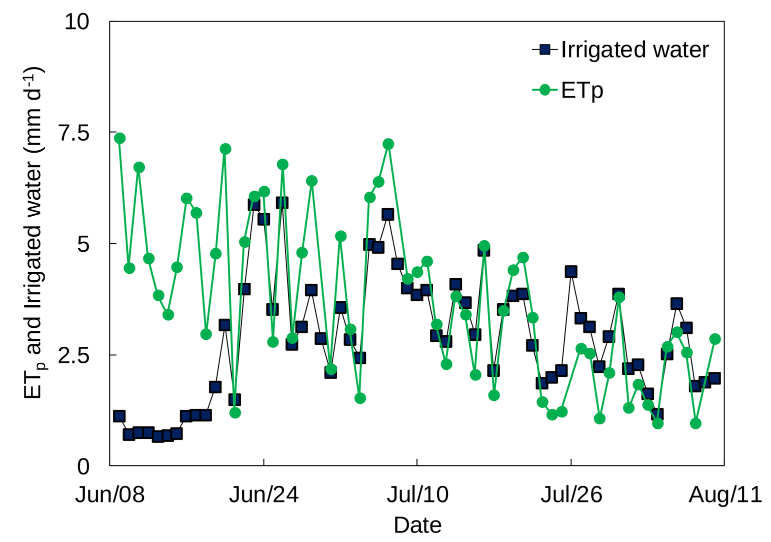

Fig. 6 Changes in irrigated water and ET_p