2.9 Activities of Post Doctoral Researchers

(1) Dr. Katsumi Ohyama

Summary of research

Improvement of a Fog System for Greenhouse Cooling

Application of a fog system to greenhouse cooling has been examined for over 20 years in terms of cooling performance, system design, and uniformity of interior environmental conditions. Despite the fog system requires less initial cost compared with that of other cooling systems such as pad-and-fan systems, application of the fog system is still limited in Japan and many other countries. Only 1,000 ha, which accounts for two per cent of the total greenhouse area in Japan, are equipped with the fog systems. A possible reason for its limited use is a poor control method for the fog system, which sometimes results in undesirable air temperature and relative humidity inside the greenhouse. In this study, to solve the problems and for further extension of the fog system for greenhouse cooling, the following experiments have been done: 1) development of a method for determining psychrometric status of the air inside the greenhouse during operation of the fog system, 2) improvement of the method of fog generation, 3) theoretical consideration of its cooling efficiency, and 4) development of a control algorism.

Publications:

1. Ohyama, K., Omura, Y. and Kozai, T. 2005: Effects of air temperature regimes on physiological disorders and floral development of tomato seedlings grown under continuous light. HortScience (in press)
2. Toida, H., Ohyama, K., Omura, Y. and Kozai, T. 2005: Enhancement of growth and development of tomato seedlings by extending the light period each day. HortScience 40: 370-373
3. Ohyama, K., Manabe, K., Omura, Y., Kubota, C. and Kozai, T. 2005. Potential use of a 24-h photoperiod (continuous light) with alternating air temperature for production of tomato plug transplants in a closed system. HortScience 40: 374-377
4. Ohyama, K., H. Murase, S. Yokoi, T. Hasegawa and T. Kozai. 2005: A precise irrigation system with an array of nozzles for plug transplant production. Transactions of the ASAE 48: 211-215
5. Kozai, T., T. Itagi, K. Okabe, K. Ohyama. 2005: Closed systems with artificial light for transplant production. Yokendo, Tokyo (in Japanese)

(2) Dr. Tadaomi Saito

Summary of research

1. Calibration method of dielectric soil moisture sensors considering the effect of salt concentration

Moisture sensors based on dielectric constant tend to overestimate the soil water content with the increase of salt concentration. To accurately determine water content with dielectric sensors, the concentration-specific calibration would be required. This study proposes a calibration method of dielectric sensors considering the effect of salt concentration. Salt concentration can be measured with a four-electrode electrical conductivity sensor with relatively low cost.

I developed calibration equations for both dielectric sensors and a four-electrode sensor. Both sensor output depend on water content and the electrical conductivity of soil solution. I thus solved simultaneous equations. Two different types of commercially available dielectric sensors were calibrated: the ECH_2O probe and the ThetaProbe−ML2. Calibration experiments were carried out using Tottori dune sand uniformly packed in covered containers at a constant temperature, for NaCl concentrations ranging from 0 to 31.9 ds/m, and for volumetric water content values ranging from 0 to 0.335 cm^3/cm^3.

Results showed that solving simultaneous calibration equations allowed accurate estimations of water content for both the ECH_2O Probe and the ThetaProbe. The ECH_2O probe was more inexpensive, but showed stronger dependence and nonlinearity on salt concentration than the ThetaProbe. Thus the fitted experimental equations of ECH_2O probe were more complex and estimation accuracy of water content was lower than the ThetaProbe. Considering high dependence of the ECH_2O probe on salt concentration, the ECH_2O probe needs simultaneous use of the electrical conductivity sensor in application to saline soil.

2. The evaporation reduction effect of the water harvesting using a ditch filled with highly permeable material

This study is about a method of water harvesting, which promotes water infiltration and evaporation reduction in arid and semi-arid regions. In order to collect water from runoff and store it in soil, a ditch was dug and filled with a porous material. To evaluate this method quantitatively, laboratory experiments and analysis through the Hydrus2D simulation model were carried out. Five highly permeable materials were used in the ditch.

Experimental results showed that the highly permeable ditches could infiltrate the water into the soil rapidly and prevent more than 20-40% of evaporation quantity as compared with a non-ditch. Therefore, it was confirmed that the highly permeable ditch effected infiltration acceleration and evaporation reduction. The ditch filled with large pore materials provided better results because they could infiltrate much water inside of their pores, however evaporation quantity were nearly equal compared with that of smaller pore materials. The results computed by simulation modeling fit in well with measured values in the infiltration process, but some problems remained in the drying process model.

Publications:

1. Saito, T., Abe Y., Suganuma, H., Tanouchi, H. and Yamada, K. 2004: Spatial variability of soil permeability and soil depth in arid land, Proceedings of the 2004 Meeting, the Japanese Association for Arid Land Studies, pp.31-32. (in Japanese)
2. Saito, T., Abe Y., Yamamoto, T., Inoue, M. and Yamada, K. 2004: Relationships between Soil Physical Properties and Vegetation and Topography in Arid Land, Western Australia, The 59th Meeting in CYUGOKU and SHIKOKU branch of The Japanese Society of Irrigation, Drainage and Reclamation Engineering, pp.65-67. (in Japanese)
3. Saito, T., Fujimaki, H. and Inoue, M. 2004: Dependency of ECH_2O soil moisture probe on salt concentration and calibration method, The 46th Meeting of Japanese Society of Soil physics, pp.48-49. (in Japanese)