

VARIABILITY IN SOIL WATER CONTENT AND SENSOR-BASED IRRIGATION SCHEDULING FOR PROTECTED GINSENG PRODUCTION

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ABSTRACT

Ginseng is one of important medicinal plants, especially in Asian countries including Korea. Korean ginseng is mostly grown in sun-block facility on ridges, and irrigation would be critical for better production. Conventionally no irrigation or timer-controlled irrigation based on experience was practiced, and variability of soil water content and sensor measurements has not been considered. Objectives of the study were to investigate variability of soil water content, and to evaluate sensor-based irrigation scheduling. Experiments were conducted in a sun-block ginseng production field. First, soil water content was measured at 9 locations in each 1 m by 1.6 m ridge section at 2 depths (i.e., 0-12 cm, 0-20 cm) using two commercial sensors. Differences in soil water content was 1~2.2% for different rows, and less than 2% within section. Next three types of irrigation scheduling were compared: no irrigation, timer irrigation (two times of irrigation when there was no rain), and sensor-based irrigation (e.g., irrigation when the sensor reading was less than 19%). The sensor-based scheduling resulted in water saving of 22% and root growth increase of 20%, compared with the conventional timer irrigation. Further research on determination of optimum sensor location and real time irrigation control would be useful.

Keywords: Ginseng, Irrigation, Soil water content, Variability, Sensor

INTRODUCTION

Ginseng is one of important medicinal plants, especially in Asian countries including Korea. In Korea, area and yield of ginseng production were 12,400 ha and 13,700 ton in 2000, increased to 16,400 ha and 19,900 ton in 2006, respectively, and recently ginseng has also been grown in paddy fields. To secure international competitiveness, however, field operations such as seedling grading and sorting, irrigation, and harvesting should be mechanized.

Korean ginseng is mostly grown in sun-block facility on ridges, and irrigation would be critical for better production. Soil water content is critical factor for root penetration and plant growth, and suitable content for ginseng is about 60% of field capacity. Among growing stages, the period of young seedling is very sensitive to soil water content, and additional irrigation would be required for sun-block facility. Management of soil water content by irrigation is necessary, especially when root penetration into the soil and growth is progressing (Cho et al., 1998).

State of soil water is expressed in volumetric content (%) or matric potential (kPa). Volumetric soil water content is traditionally determined by the oven-dry method that requires soil sampling from the fields and analysis in the laboratory, requiring time and cost, therefore in-situ measurement using electronic sensors would be preferable (Hillel, 1980). Sensor types could be divided into FDR (Frequency Domain Reflectometry) that determines water content by measuring capacitance and/or impedance of the soil, and TDR (Time Domain Reflectometry) that uses dielectric properties of the soil (Topp and Ferre, 2002).

Soil water content may not be uniform across the production field (Chung et al., 2005), and conventionally no irrigation or timer-controlled irrigation based on experience was practiced, and variability of soil water content and sensor measurements has not been considered. Objectives of the study were 1) to investigate variability of soil water content, and 2) to evaluate performance of a sensor-based irrigation, in a sun-block ginseng production field.

MATERIALS AND METHODS

Experiments were conducted in a sun-block ginseng production field, College of Agriculture and Life Sciences, Chungnam National University, Daejeon, Republic of Korea. First, variability of soil water content was investigated. The sun-block facility was composed of 1.6 m by 1 m sub-sections, and the experiments were carried out 2 rows of the 10 sub-sections (16 m by 1 m), as shown in Figure 1. In each sub-section, 3 replicate measurements were obtained at equally spaced nine locations. Commercial sensors used in the study were a FDR sensor (Model: WT1000¹, RFSSENSOR, Seoul, Korea) and a TDR sensor (Model: Hydrosense, Campbell Scientific Inc., Logan, Utah, USA). Specifications of WT1000 were $\pm 3\%$ accuracy, 0-

¹ Mention of trade names or commercial products in this paper is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the authors or their institutions.

60°C operational ambient temperature, and 12-cm long sensing electrodes with 3-cm spacing. Hydrosense had $\pm 3\%$ error, 0.25% resolution, 12- or 20-cm long sensing electrodes with 3.2-cm spacing. Soil water contents were compared by sensor, location, and depth.



Figure 1. Measurement of soil water content variability using 2 commercial sensors at different locations and depths.

Next, sensor-based irrigation was implemented and the performance was compared with the timer-based irrigation and no irrigation methods. As shown in Figure 2, nine sub-sections of the sun-block ginseng production facility were used; each method was implemented in three sub-sections. No irrigation means that no additional irrigation was performed other than precipitation. For timer-based irrigation, 8 L/section of water was irrigated at 9 am and 5 pm in case that no precipitation more than 1 mm lasted 1 week. For sensor-based irrigation, WT-1000N was used to measure soil water content, and irrigation was performed when the measurement was less than 19%, corresponding to 60% of the field capacity.

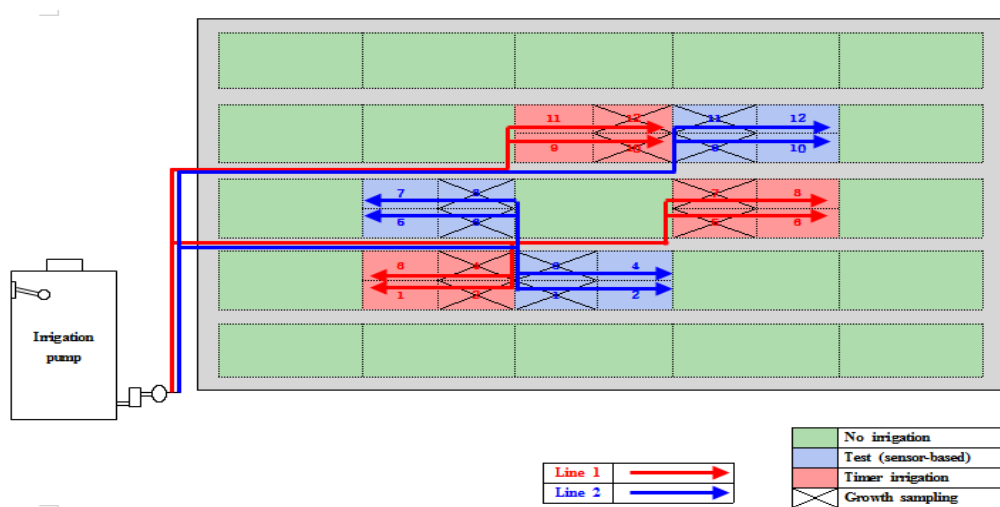


Figure 2. Schematic diagram explaining performance evaluation of the sensor-based irrigation scheduling, as compared with the timer-based irrigation and no irrigation.

RESULTS AND DISCUSSION

Figure 3 shows distribution of soil water content in the two rows and at the two depths. For both sensors, differences in soil water content were 1~2.2% for different rows. Averaged values at the front, middle, and back locations were 23.9, 23.2, and 23.0% in row A, and 23.1, 21.2, and 20.8% in row B, respectively, therefore overall ranges were less than 2%. However, the measurements showed considerable variability (up to about 10%) along the sub-sections, therefore measurements for irrigation scheduling should be taken at locations where status of water requirement could be representative.

When CS620 was used, average and standard deviation were 23.4 and 2.4% for the 20-cm electrodes and 21.7 and 3.7% for the 12-cm electrodes in row A. They were 24.2 and 3.0% for the 20-cm electrodes and 19.5 and 2.9% for the 12-cm electrodes in row B. Differences of the water contents between the rows were less than 2.2%, and those between the depths were 1.7% in row A and 4.7% in row B, respectively. Average values measured by WT-1000 were less than those by CS620 by about 3%.

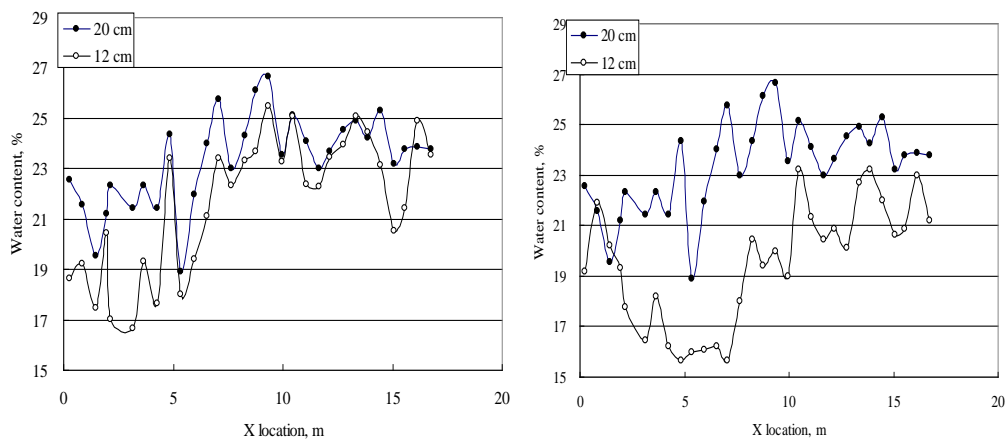


Figure 3. Distribution of soil water content in the two rows and at two depths.

Next three types of irrigation scheduling were compared: no irrigation, timer irrigation (two times of irrigation when there was no rain), and sensor-based irrigation (e.g., irrigation when the sensor reading was less than 19%). The sensor-based scheduling resulted in water saving of 22% and root growth increase of 20%, compared with the conventional timer irrigation, as shown in Figure 4. Further research on determination of optimum sensor location and real time irrigation control would be useful.

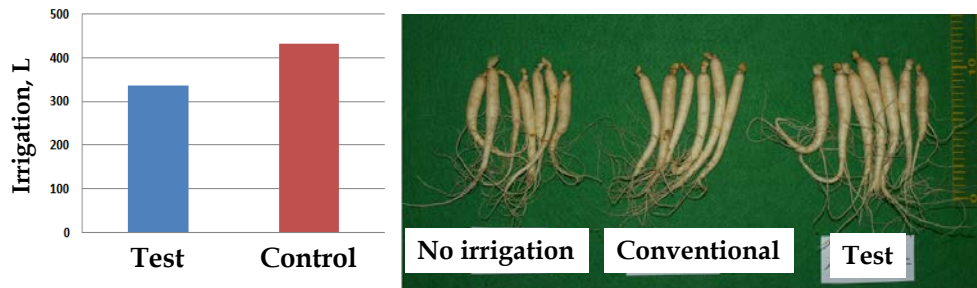


Figure 4. Comparison of irrigated water (left) and ginseng growth (right) by irrigation methods.

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