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Study on estimation of volume water content in grove soil using handheld sound source and sensors.
簡易型音源及びセンサを用いた植物栽培土壌中の体積含水率の推定に関する検討

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1. Introduction

In late years, a problem of the global water shortages especially in developing countries becomes clear, and is told that efficiency of the agriculture water is necessary[1]. To that end, grasp of water distribution as one of the parameters to affect plant upbringing in the soil is particularly necessary. However, the existing soil water evaluation method is the point measurement using the soil moisture sensor. Therefore, the practical use is difficult because a large number of sensors are necessary to measure a wide range around the plant root zone.

On the other hand, the sound wave propagation has a possibility that the water distribution around the plant root zone can be estimated with a small number of sensors. We confirmed that both horizontal and vertical propagation velocity distribution is related to the water distribution using SLDV (Scanning Laser Doppler Vibrometer) experimentally[2-3]. Though the measurement using the laser is not realistic, by inserting a stick type sound source and sensors perpendicularly for the soil, the growth situation of the plant in the rooting zone has a possibility to grasp from the distribution of the propagation velocity.

Therefore, in this study, we proposed a soil water distribution measurement using sound wave vibration. This time, using stick type sound source and sensors, sound wave propagation measurement in shallow underground and a propagation velocity of sound when water distribution existed are studied.

2. Principle of proposed method

Figure 1 shows the conception diagram of our proposed method. Using the negative pressure difference irrigation system, water distribution in the soil is formed in plant rooting zone. From the distribution of the propagation velocity of sound, water distribution is estimated around the rooting zone. Utilizing the water distribution information, the irrigation system is controlled to supply only the water which a plant needs.

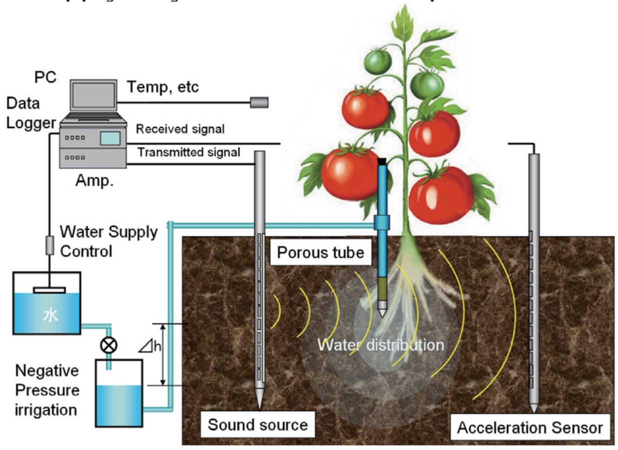

Fig. 1. Fundamental concept of our proposed method.

3. Stick type sound source and sensors

Fig.2(a) shows the profile of the stick type transmitter (326×30×30mm^3). There are five

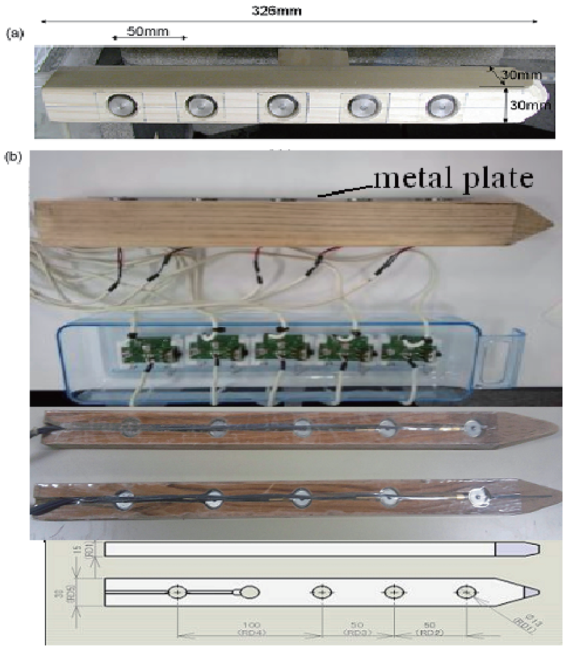

Fig. 2. Stick type sound source & sensors.
(a) Transmitter, (b) Receiver.

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circular holes in the housing (conifer materials), and has small giant magnetostriction vibrator (OPT Co., Ltd, GPECKER) built-in. Each vibrator head is fixed on metal plate. Fig.2(b) shows the profile of the stick type receiver ($300\times30\times15mm^3$). There are five circular holes in the housing (broad leaf tree), and has acceleration sensor (Ono Sokki Co., Ltd., NP-3110) built-in. Each sensor's head is glued together with a PP (polypropylene) sheet affixed to the wood surface. The main body of giant magnetostriction vibrators and sensors are not adhered to the housing.

4. Basic experiment for propagation velocity measurement in culture soil

Using a transmitter and a receiver, propagation measurement in culture soil was performed. Figure 3 shows the experimental setup using a tank ($500\times400\times300mm^3$). The distance between a sound source and a sensor is 15cm, moisture content of culture soil is 20%.

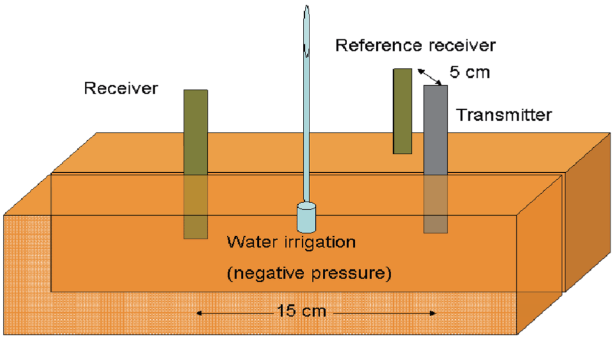

Fig. 3. Basic setup for vibration propagation measurement.

Figure 4 shows the examples of the received waves using sine burst wave (500Hz, 5cycle). From this figure and transmitter wave, propagation velocity can be measured by the distance of 15 cm. I

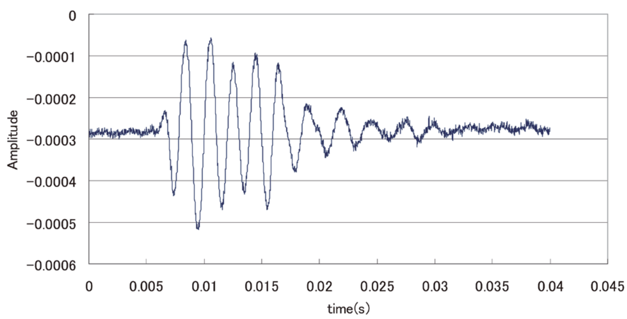

Fig. 4. Examples of waveform; 15cm distance from transmitter

5. Change of the propagation velocity by the water distribution

By drip irrigation in the tank inside, water distribution change with time is generated, and measured the change of propagation velocity and volume water content for the comparison with the stick type sensor and soil moisture sensor. Negative pressure irrigation is performed at the center of Fig. 3. To form water distribution in the soil, negative pressure level(⊿h in Fig.1) is set at 5 cm. The position of top of water irrigation tube is 10 cm depth from the soil surface. The water supply is performed as shown by Fig.5. Soil moisture sensors are buried at the depth of 5,15,25,35 cm from soil surface. Measurement result is shown in Fig.6. From this figure, volume water content by a soil moisture sensor is according to water supply. At the same time, we can confirm propagation velocity changes according to the volume water content.

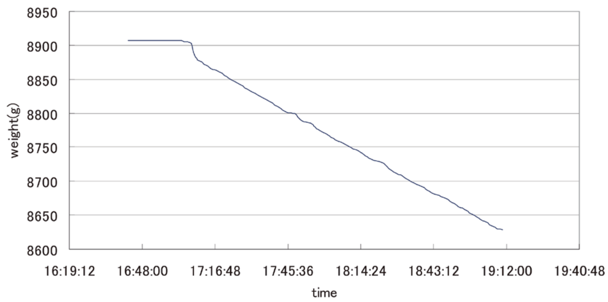

Fig. 5. Water supply (weight loss of water reserve tank)

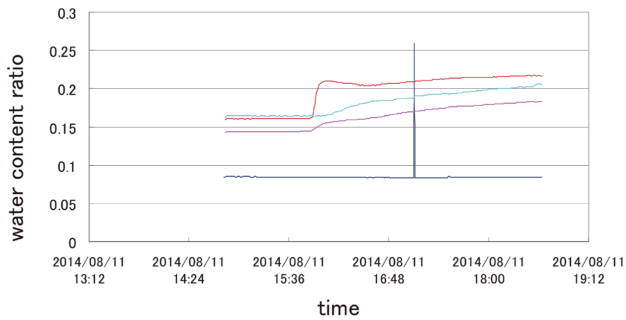

Fig. 6. Change of water content ratio by soil moisture sensors.

Acknowledgment

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