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Study on Water Distribution Imaging in the Soil using Propagation Velocity of Sound, -The Horizontal and the Vertical Water Distribution Imaging-

伝搬音速による土壌水分分布映像に関する研究,
−水平および縦方向の水分分布映像−

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1. Introduction

Global shortage of water is approaching as realistic fear now. Population growth and abnormal weather are cited as this cause. However, a lot of studies on saving water of the agriculture water are performed because the use of most water is agriculture water. On the other hand, the negative pressure difference irrigation method that can be supplied with water from the underground attracts attention [1]. This method can supply water that the root of the plant needs. Therefore there is an advantage to be able to reduce water supply in comparison with the ground surface drip irrigation method. However, the dynamic optimal control cannot be performed because it is difficult to grasp water distribution in the soil. Thus the acoustic imaging using the sound wave vibration is proposed to measure water distribution of the rooting zone in this study [2-3]. This time, the water distribution measurement of the horizontal and the vertical direction in the sand tank was examined.

2. The Measurement Method

To consider whether a change of water content was examined by a change of the propagation speed of sound, SLDV (Polytec Corp., PSV400-H4) and the sound source are used. SLDV measures the vibration of ground surface excited by sound wave caused from vibration source. Using the vibration waveform and the output waveform calculates the propagation velocity from vibration source to the measurement point. There is a difference in the average of propagation velocity in sand and water. When passing water distribution, the propagation velocity is expected to be fast. On the basis of this supposition, water distribution can be estimates. Sand is used as soil (Average particle size is 200-300um).

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3. Water distribution imaging experiment for horizontal direction using negative pressure difference irrigation system

Figure 1 shows an experimental setup for horizontal direction when using negative pressure irrigation system. The porous pipe which is made from ceramic is installed in the about 18 cm height from the sand tank base and the level control tank is installed in the position with the low of about 20 cm from the height of the porous pipe. The rate of the water which is supplied to ground by this height is decided. The vibration measurement measured in the interval of 10 minutes and measured until 90 minutes.

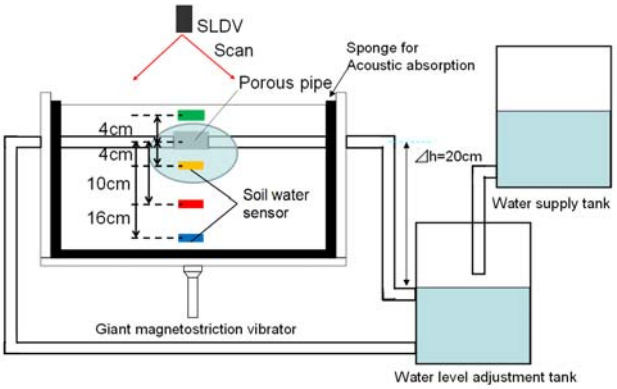

Fig. 1. Experimental setup of water distribution imaging for horizontal direction when using negative pressure irrigation system.

A result of imaging in each time is shown in Fig.2. From this figure, we can confirm that water distribution is temporally changed. The graph of average with the volume water content which measured by four sensors and the graph of the average with the propagation velocity which was measured at nine points of the near the porous pipe is shown in Fig.3. We think that the water distribution reaches a base in this time zone because the value isn't changing about 40 minutes later after beginning in the measurement from Fig.2. At the

same time, the value isn't changing in the approximately similar time zone about the propagation velocity, too. In other words, we can confirm that the influence to the propagation velocity when changing the volume water content of the water distribution.

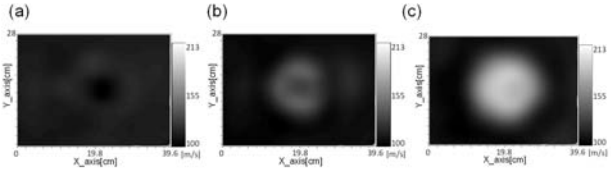

Fig. 2. The results of imaging of sound velocity distribution in each time. (a) 20minutes, (b) 50minutes, (c) 80minutes.

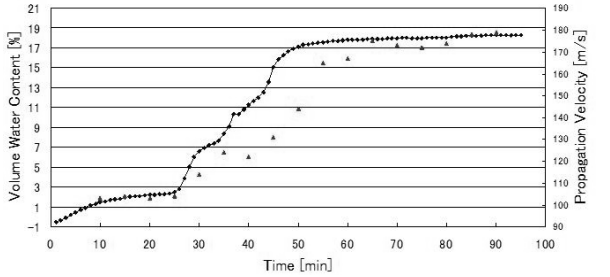

Fig. 3. Experimental result of the volume water content and the propagation velocity. Diamond: Volume water content [%] , Triangle: Propagation velocity [m/s].

4.Water distribution imaging experiment for vertical direction using negative pressure difference irrigation system

Figure 4 shows an experimental setup for vertical direction when using negative pressure irrigation system. The porous pipe which is vertically installed in the about 22 cm height from the sand tank base and the level control tank is installed in the position with the low of about 10 cm from the height of the porous pipe. A measurement board with holes was made to measure the real time process when the water in the sand spread in the vertical direction. A thin film (polypropylene sheet) of thickness approximately 60μm is attached to prevent an outflow of the sand between a measurement board and the sand. The sand vibration can be measured through this film. A flat speaker (FPS Corp. FPS2030M3P1R) is used as a sound source instead of a magnetostriction vibrator. This is because the stability of the lateral installed vibrator. A sinusoidal burst wave of 4kHz, 5cycles are used as a transmitted wave.

A result of imaging in each time is shown in Fig.5. From this figure, we can confirm that vertical water distribution is temporally changed. The propagation speed of sound around the porous pipe begins to rise after irrigation, and we can confirm that high speed area spreads through the vertical direction with time. As shown in Fig.6(a), the volume water content was measured by the soil-moisture sensors. And the graph of the average with the propagation velocity which was measured at nine points of the near the porous pipe is shown in Fig.6(b). Compared with these result, it seems that these values change in approximately similar time. Therefore, we can confirm that the influence to the propagation velocity when changing the volume water content of the water distribution.

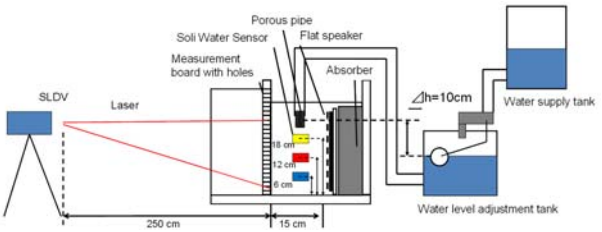

Fig. 4. Experimental setup of water distribution imaging for vertical direction when using negative pressure irrigation system.

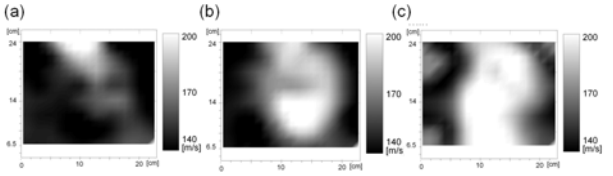

Fig. 5. The results of imaging of sound velocity distribution in each time. (a) 14minutes, (b) 32minutes, (c) 54minutes.

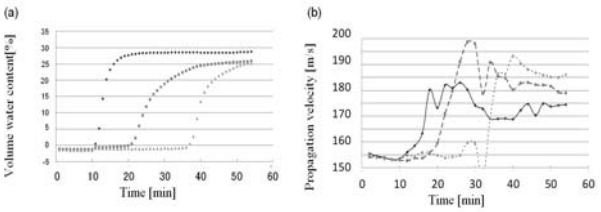

Fig. 6. Experiment result. (Water moisture sensor installed position ◆: 18cm, ■:12cm, ▲:6cm from the bottom of the sand tank. (a) The volume water content which measured by three sensors, (b) Estimated propagation velocity near the sensor position.

5. Conclusion

This time, we can confirm that it was caught in the water distribution which changes time wise by measuring at both direction of the vibration measurement. In the future, we plan to review the improvement of the estimated precision of the volume water content by the vibration measurement. And, we intend to examine whether our method can apply even in the case that a plant is growing up in soil for gardening.

References

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