Precision Water Saving Cultivation Focused on Water Retention Zone
保水領域に着目した精密節水農法の研究

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Water shortage has become a serious problem across the global. And this problem will be worse in the future due to the growth of the world population and the climate change. How to improve water use efficiency (WUE) in agriculture to meet the growing demand for food, feed, fiber and fuel has become an urgent issue. The precision agriculture (PA) approach has shown a great potential in agricultural management to improve the water and fertilizer use efficiency based on the information and measurement technology. To implement the PA approach in irrigation management to improve the WUE in crop production, this study presented a new cultivation method by keeping the minimum moisture necessary for plant growth only in crop rooting zone, and harvested fruits by using only a few percent of normal irrigation water. Also, this study attempted to observe water dynamics in the rooting zone and the plant physiological response to the irrigation water. As a result, it is possible to analyze the irrigation waste against the water requirement of plant organism from the view point of water volume necessary for plant growth. This study analyzed the irrigation water use efficiency which is not clearly understood in the existing studies. The knowledge gained in this study may contribute to the development of water saving agriculture. Furthermore, based on the fact that the water retention can be controlled within plant rooting zone, the morphological feature of root and the root hydrotropic response to the wet soil condition were able to be precisely observed and analyzed under the controlled
condition which cannot be realized in the existing studies.

In order to evaluate the current water saving cultivation system in Japan, this study firstly investigated the spatial variation of soil moisture in a field. In the survey, a sloped citrus field with mulch drip irrigation system was selected and the soil moisture was measured at three points in the depth direction using a capacitance soil moisture sensor. To visualize the results, the measured soil moisture with RTK-GPS location data was used to develop geographical soil moisture map by the ArcGIS tools. And the field moisture variation was shown in both horizontal and vertical direction. As a result, moist moisture distributed in the deeper soil, which confirmed the irrigation water lost due to gravity. This study also attempted to measure the soil moisture and nutrients by spectroscopic methods and evaluated its prediction accuracy towards 24 soil parameters (Chapter 2).

Next, in order to maximize irrigation efficiency to agricultural crops, this study practically verified whether the state that moisture exists only in crop rooting zone can be stably controlled. Experiments were carried out under an artificial climatic environment. Irrigation was done manually through point water source to the rooting zone. Tomatoes were used as cultivars. Homogenous soil was used which was artificially dried and sieved. Temperature, humidity and solar radiation were set artificially, while only the irrigation volume was used as the control parameter. In order to precisely grasp the moisture dynamics in the rooting zone, the moisture condition was measured by higher resolution of centimeter order soil moisture sensor matrix. Cultivation experiment was conducted to stably create water retention in limited and small soil area around crop rooting zone by finely controlling water volume and timing based on the observed soil moisture dynamics. This study quantitative analyzed the plant growth in response to the water to know the relationship between crop growth and the irrigation water volume. In this experiment, the irrigation water was attempted to be saved to a limit for plant growth, and cultivated the plants until first fruit was harvested. An average of less than 50 ml of irrigation water per day was used which was only a few percent of the normal irrigation volume. The water use efficiency and the morphological features of the roots were then analyzed under this extremely water saved condition (Chapter 3).